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STRENGTH OF WOODEN COLUMNS.

REPORT OF CERTAIN TESTS

ON

FULL-SIZE WOODEN MILL-COLUMNS,

MADE FOR

Boston Manufacturers Mutual Fire Insurance Co.

UNDER THE DIRECTION OF

PROF. GAETANO LANZA, S.B., C.E.,

Of the Massachusetts Institute of Technology.

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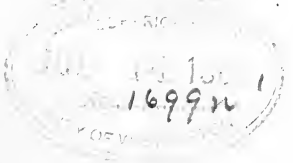

BOSTON: 1882.

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STRENGTH OF WOODEN COLUMNS.

To the Boston Manufacturers Mutual Fire Insurance Company.

Gentlemen:—

Eight or nine months ago, your President, Mr. Edward Atkinson requested me to superintend some computations on the strength of wooden beams, and columns. He desired that I should direct what constants, and what formulæ should be used in the calculations. In regard to the beams, although our data are untrustworthy, inasmuch as almost all of them have been derived from experiments made upon very small beams, nevertheless, I caused the computations to be made, with such constants as my judgment told me were the most reliable.,

In regard to the columns, I reported to him nat the experimental data, on which are based the rules for the determination of the strength of wooden columns, were so few, and so imperfect, that there were no formulæ by which it would be at all safe to make the desired computations, and that the only course that lay open to him was to send some columns to the Watertown arsenal, and have them tested on the government testing machine. He, thereupon, decided to have the tests made, and asked me to take charge of them.

Of the rules and formulæ for the computation of the strength of columns the oldest are those of Euler, and, so far from having gone out of use, they have been employed at a very recent date by prominent French engineers in computing a very important construction. This theory assumes that it is possible to determine a definite ratio of length to diameter, different for every different material, and that all columns the ratio of whose lengths to their diameters is less than this number give way by direct crushing, whereas those which have the ratio of their lengths to their diameters greater than this number, give way wholly by transverse bending. His formulæ for the strength of such circular columns as yield by bending, are as follows:

For ends fixed in direction $P = \frac{(3,1416)^3}{16} E \frac{d^4}{l^2}$

For rounded ends $P = \frac{(3,1416)^3}{64} E \frac{d^4}{l^2}$

where P = breaking weight in pounds, E = modulus of elasticity of the material. For wood, Weisbach gives for use in Euler's formulæ E = 1,664,000 and crushing strength per square inch = 6770.

Eaton Hodgkinson made a very extensive series of tests on columns, especially of cast iron, and deduced from these tests certain empirical formulæ. These tests form, even at the present day, the basis of the most used formulæ for the strength of columns. The strength of pillars of the ordinary sizes used in practice has been computed by means of Hodgkinson's formulæ and tabulated by Mr. James B. Francis, and we find in his book the following rules for the strength of solid cylindrical pillars of cast iron with the ends flat, i. e., "finished in planes perpendicular to the axis, the weight being uniformly distributed on these planes." For pillars whose length exceeds thirty times their diameter, he gives the formula:

$$W = 99,318 \frac{d^{3.55}}{l^{1.7}}$$

for the breaking weight in pounds, where d = diameter of column in inches, and l = length in feet.

If, on the other hand, the length does not exceed thirty times the diameter, he gives for the breaking weight the following formula:

$$W' = \frac{W c}{W + \frac{4}{3} c}$$

where W = breaking weight that would be derived from the preceding formula; W' = actual breaking weight; c = weight which would crush the pillar; or $c = 109,801\ (.7854 d^2)$.

If the pillar has rounded ends, take one-third of the above result.

For wooden pillars of Dantzic oak, take one-ninth of the breaking strength of a cast iron pillar.

Mr. Lewis Gordon devised semi-theoretical formulæ for the strength of columns, which were founded on the assumption that they gave way by a combination of crushing and bending, and which also involved other assumptions, a part of which were those ordinarily made in regard to the transverse strength of beams. The constants used were determined in such a way as to make the results agree as nearly as possible with Hodgkinson's experiments. The formulæ devised by Gordon himself only refer to cylindrical and hollow

cylindrical columns. A formula devised by the same course of reasoning and also depending, for its constants, on Hodgkinson's experiments, but so arranged as to be applicable to any form of section whatever, is given by Professor Rankine. For wood it is as follows:

$$P = \frac{7200\,S}{1 + \frac{l^2}{3000\,r^2}}$$

where P = breaking strength in pounds;
S = sectional area in square inches;
l = length in inches;
r = least radius of gyration in inches.

Besides the above we have formulæ which are practically Rankine's formulæ, with the constants changed. One of these is that of Mr. C. Shaler Smith as given in Trautwine's pocket book, and applicable, as he claims, to a square or rectangular column of white or yellow pine. It is as follows:

$$P = \frac{5000\,S}{1 + .004\frac{l^2}{d^2}}$$

where P = breaking weight in pounds;
S = sectional area in square inches;
l = length in inches;
d = least side of rectangle.

I have computed by means of these formulæ the breaking weights of certain oak columns, with the following results:

Length = 14 feet.

		Diameter 10.5 inches.	Diameter 9.5 inches.
Euler.....	Flat ends.....	386,214.	479,853
	Rounded ends.....	347,147.....	232,623
Rankine	Flat ends.....	465,261	360,164
	Rounded ends.....	263,615.....	191,286
Francis..	Flat ends.....	420,000.....	312,795
	Rounded ends.....	140,000.....	104,265

If we use the average of the results obtained from the oak columns that I tested at Watertown, we should find for the breaking weights of the above columns with flat ends, about 277,000 lbs., and 227,000 lbs. respectively.

A glance at the above results will show that they differ very much from each other, and the question naturally arises as to the trustworthiness of the experimental data on which they are based.

The constants used in Euler's formulæ are not deduced from any experiment on the breaking of a column.

Rankine's and Francis's have for experimental basis, the experiments of Hodgkinson. He made a very large number of tests of cast-iron columns, none of which were as large as those used in practice. On oak columns, he made seventeen experiments on as many columns, all cut from one good plank of Dantzic oak, the largest of which was five feet long and two inches square. Of these seventeen only seven were used in deducing his formulæ.

It is plain that such data are insufficient and cannot furnish us reliable information as to the strength of a column.

Moreover, we have the following facts, as showing the difference of behavior of large and small specimens under test: An iron rod, five inches in diameter, which was tested on the government testing machine at the Watertown arsenal, broke under a tensile stress of only 36,000 lbs. per square inch, notwithstanding that it was claimed by the makers to be of very superior quality, and if tested in small specimens would have borne very much more. In the Journal of the Franklin Institute, for September, 1880, we find it stated that Professor Thurston, from four experiments on large beams of yellow pine, obtained as modulus of elasticity 1,387,000 pounds per square inch in place of 2,078,000, which he had obtained from tests made on small beams of the same kind of wood.

Having thus fully defended, as it seems to me, the recommendation I made to Mr. Atkinson, I will add, that besides five tests on full size yellow pine columns, and about six on full size spruce columns made by Colonel Laidley at the Watertown arsenal, I know of no other tests of full size wooden columns except a few made by Mr. Kirkaldy on pine columns twenty feet long and thirteen inches square; and Trautwine claims that the results of these tests agree well with the formula of Mr. C. Shaler Smith. Such agreement must, however, be confined to those special dimensions, inasmuch as a square yellow pine column, twelve feet long and eight inches square, would, according to Mr. Smith's formula, have for its breaking strength 140,000 lbs., whereas having actually broken a yellow pine post of about that size, I found for its breaking strength 375,000 lbs., which shows that Mr. Smith's formula does not furnish correct results for all sizes.

Passing now to consider the experiments which are to form the subject of my remarks I will say that there have thus far been two series of tests, the first made in June and the second in November, 1881.

In the case of the first series it was Mr. Atkinson's desire that neither he nor I should take any part in the selection, and hence a

carpenter was directed to furnish ten columns suitable for use in a mill. Four of them were of yellow pine, four of white oak, and two of white-wood. They were all twelve ft. long, all were tapered from bottom to top, and all were bored, and we supposed at the time that they had a longitudinal hole extending from end to end to allow a free circulation of air, and hence to prevent checking and dry rot. The larger diameters varied from about 10.5 inches to 7.75 inches, whereas the smaller varied from about 9.3 inches to about 6.4 inches.

The pine was of very fair quality, and not thoroughly seasoned. The oak came almost directly from the woods and was very green, and also very knotty.

All the tests in the first series were made by compressing the columns directly between two parallel plane surfaces, so that these columns were all in the condition of flat-ended columns, or columns with their ends fixed in direction. In all but two cases fracture occurred near the small end of the tapered posts, indicating that the fracture was one of direct crushing, and that the breaking strength per square inch could be correctly found by dividing the breaking load by the number of square inches in the section at the smaller end. The immediate location of the fracture was generally determined by knots, whenever there were knots near the small end of the post, the knots apparently causing the fibres in their vicinity to be curved, instead of straight, and hence reducing the effective bearing area, nevertheless, the fracture near the small end occurred in perfectly straight-grained posts, as well as in those where there were knots.

Both horizontal and vertical deflections were measured in all cases, sometimes only at the middle of the posts, and sometimes at other points also. The numbers given in the tables in the deflection columns, are the horizontal and vertical distances of given points on the columns from fixed datum lines, and hence the deflections under any given load will be found by subtracting the first of the readings from those corresponding to the given load, thus, in yellow pine post No. 1, 1st series (as shown in the accompanying tables), the horizontal middle deflection was 0.09 in. and the vertical 0.03 in., when the load was 180,000 pounds.

An examination of the tables will show that the deflections in this first series of tests remained always very small (almost inappreciable), until the load had nearly reached the breaking strength, and that when the deflection began to be of appreciable magnitude it was a sign that the column was begining to fail; also that, except in the two exceptional cases above referred to, the deflection was quite small even when the post was near fracture, showing that the deflection played a quite insignificant part, if any, in the breaking of the posts, so insignificant that a little crooked grain or a small knot would have more influence than the deflection. Indeed, in the case of the posts tested at the Watertown arsenal by Col. Laidley, the longest of which was about 10 diameters in length the deflection was never measured, so confident was he of their breaking by direct crushing.

That columns whose ratio of length to diameter is much greater, will give way by bending, is of course true, but what is the precise point at which bending begins to have an appreciable influence in the fracture of posts with their ends fixed in direction, and whether such is the case in any of the ordinary mill columns is a question that can only be determined by experiment. Now as to the crushing strength per square inch we have from this first series of tests an average value of

4300 lbs per square inch for yellow pine.
3500 " " " " " white oak.
3000 " " " " " whitewood.

and these results will be found to difier very considerably from those most commonly given in the books. How and why, I will show when I speak of the second series of tests.

As to the two posts that gave way by bending, one was yellow pine post No. 2, and in this case the failure was evidently caused by a large knot near the middle of the length of the post with season cracks around it, the knot acting like a wedge and widening the season cracks, and causing the post to weaken and then to bend. At 60,000 pounds there was no measurable deflection, neither was there any at 120,000 lbs., nor at 150,000. When the load became 180,000 lbs. the deflection became about 0.02, then a load of 190,000 lbs. was put on and left through the dinner hour, and before the end of that time the post had failed, the season cracks opening and the post bending with the knot on the concave side. The behavior of this column shows very plainly the importance of determining experimentally the power of columns to endure a load for a long time. Had the load of 190,000 lbs. not been left, but the load increased, it is probable that the column would have borne a load as

great as 210,000 pounds, but the 190,000 lbs. was already causing permanent injury to the fibres near the point of subsequent fracture.

The other post that failed by deflection was white oak post No. 2, which contained about thirty knots, the greater part of which were very small. There was, however, a very large one near the centre, but fracture was apparently in no wise influenced by the it, but was produced by the fact that the hole bored in the post for the admission of air was out of centre at the middle. The deflection again was very small until the load reached nearly the limit of strength; thus at 50,000 lbs. it was 0.02 in.; at 100,000 it was 0.04 in.; at 150,000 it was 0.06 in.; at 180,000 it was 0.07 in.; but when 200,000 lbs. was applied it rose, after five minutes, to about 0.7 in., the column rapidly failing. On examination it appeared that the holes had been in all cases bored from the two ends, and that in only one post of this series, viz., the smallest whitewood, did they meet in the centre; a section subsequently cut from yellow pine post No. 2, and shown in the figure, exhibits the great eccentricity of these holes. That such holes do not fulfil the object for which they were intended, viz., the admission of a current of air, is very plain; and also that, in that case, they are sources of weakness in the post, and are worse than no holes at all.

In the second series I made an attempt to have the holes bored straight, and, for this purpose, had them bored in a machine shop on a large iron lathe with a pump augur, the first series having been bored by hand with a screw augur. While the result was a decided improvement on the previous boring, inasmuch as there was in every case a hole clear through the post, nevertheless it was far from being such boring as ought to be done if the post is to be weakened as little as possible thereby. A section cut from post No. 4 yellow pine and post No. 1 yellow pine, of the second series, and shown in these figures, will show some of the worst of this boring.

I am fully satisfied that the holes can be bored straight, and I would therefore recommend that no post be accepted for building in which the hole has been bored from the two ends, and that, in the case of those bored clear through from one end, all be rejected, where the hole at the issuing end is more than $\frac{3}{4}$ in. out of centre. I am not disposed to recommend the turning the post down parallel to the hole, as we should thus have to cut the wood across the grain.

Before going farther I will proceed to consider in detail the behavior of the remainder of the posts of the first series:

1. White Oak No. 1.—When loaded with 50,000 lbs. the middle deflection was about 0.02 in.; with 100,000 lbs. it was about 0.03 in.; with 120,000 about 0.04 in.; with 140,000 about 0.06 in.; with 160,000 about 0.08 in.; with 180,000 about 0.13 in. The load, 180,000 lbs., remained on for 15 minutes, during which time the compression was constantly increasing, and when 190,000 lbs. was applied the deflection was again measured and found to be about 0.33 in.; the column was then in process of failing. It would probably have failed under 180,000 lbs., had sufficient time been allowed.

2. White Oak No. 3.—The deflection under 50,000 lbs. was 0.02 in.; under 100,000, 0.07 in.; under 150,000 about 0.17 in. This load remained for 15 minutes, the deflection increasing all the time, and then the load was increased to 160,000 lbs., when failure took place. The failure took place at knots near the smaller end, bending concave on the side of the knots.

3. White Oak No. 4.—Middle deflection at 50,000 lbs. was 0.01 in.; at 100,000 about 0.03 in.; at the same load after 8 minutes it became 0.12 in.; in 28 minutes 0.23 in., and would probably have failed at this load with sufficient time, but after 36 minutes the load was increased to 110,000, when the column failed at knots near the small end.

4. Yellow Pine No. 1.—This column was entirely free from knots, and (I think) also from season cracks. It failed under 270,000 lbs. by the crushing of the fibres at the small end. The deflection at 100,000 lbs. was 0.07 in.; at 180,000 about 0.09 in.; at 220,000 it was about 0.13 in.; at 260,000 about 0.17 in.; then 270,000 was put on and the post yielded rapidly.

5. Yellow Pine No. 3.—This column failed under 200,000 lbs., the fibres crumpling 4 in. to 8 in. from the smaller end where there was no knot, and also at 32 in. from the smaller end in the vicinity of a small knot. There was a double flexure produced just at the close of the test, but it is my opinion that the crumpling nearest the small end was the source of failure, and that the other was subsequent to that.

6. YELLOW PINE No. 4.—This column failed under a load of 138,000 lbs. at knots near the smaller end.

7. WHITEWOOD COLUMNS.—These gave way suddenly by breaking the fibres near the smaller end, giving no warning of fracture.

The details and all the figures of the above tests will be found in the accompanying tables, and the fractures in the cuts. Yellow pine No. 2 and No. 4 are those that were on exhibition in the Arsenal exhibit in the late fair of the Charitable Mechanic Association.

Passing next to the consideration of the second series of tests, I will state that, having reported to Mr. Atkinson the results obtained from my first set of experiments, and having made certain recommendations in regard to a continuance of the tests he authorized me to carry them on within certain limits of expense, according to my own judgment.

My first step was to order from the carpenter four yellow pine and four white oak posts of diameters respectively equal to the larger diameters of the preceding set. I directed that these posts should be procured of a length of 14 feet, and that then a two foot block should be cut from the end of each post. I desired to compare the crushing strength of the long posts with that of two foot blocks cut from the same piece of timber. My directions not having been strictly followed, I am only able to compare average values, and can only say that the blocks and posts were of about the same quality, and that some of them did come from the same pieces of timber as the corresponding posts. I then took the precautions I have already described in regard to the boring of the 12-foot columns, and left the two-foot blocks without boring. The results of these tests give nearly the same values for the crushing strength per squaae inch of the blocks, and of the posts with their ends fixed in direction. In the case of yellow pine post No. 4, *i. e.*, the smallest yellow pine, we find from the tables, a breaking strength of 205,000 lbs.; whereas the corresponding block gave way at 215,000 lbs.—the post had a hole which, at the place of failure, reduced the sectional area by about three square inches, whereas the block was not bored. Three square inches is more than enough to account for the 10,000 lbs. less strength of the post, and it is thus plain that, even in this case, where the post deflected 0.28 in. before breaking, and broke at the middle, the deflection had no appreciable part in the fracture.

The crushing strengths per square inch, as deduced from these experiments, were as follows:

YELLOW PINE.

1st series.	No. 1	4,097	
	" 2	3,661	
	" 3	4,706	
	" 4	4,600	
		17,064	4,266 = average.
2d series. Blocks.	No. 1	4,424	
	" 2	4,704	
	" 3	4,330	
	" 4	4,511	
		17,969	4,492 = average.
2d series. Posts,	No. 1	4,657	
	" 3	4,084	
	" 4	4,584	
		13,325	4,441 = average.
Average of all the above			4,396
Crushing strength obtained from square post No. 4, seasoned			5,400

WHITE OAK.

1st series.	No. 1	3,006	
	" 2	3,788	
	" 3	3,753	
	" 4	3,468	
		13,988	3,497—average.
2d series. Blocks,	No. 2	3,132	
	" 3	3,139	
	" 4	3,303	
		9,574	3,191—average.

WHITEWOOD.

	No. 1	3,333	
	" 2	2,684	
		6,017	3,009 = average.

This gives us for such yellow pine as was used in these tests an average crushing strength of about 4400 lbs. per square inch, and for the white oak 3150 lbs. per square inch.

As to the results obtained by other experimenters, we find in the Ordnance Manual the following strengths given for

YELLOW PINE.			
New Hampshire	6,279	Monongahela River	6,592
No. Carolina (pitch)	8,947	New York	4,691
Florida	8,350	Maryland	6,992
North Carolina	7,836	Massachusetts	5,800
Alabama	8,201	"	7,292
Virginia	7,867	" (pasture)	6,962
	47,480	Canada	6,000
Average	7,913	Connecticut	5,199
WHITE OAK.		"	7,089
New England	6,668	North Carolina	6,550
West New York	6,620	Alabama	5,744
Ohio	6,258	Virginia	6,905
"	9,108	Oregon	6,072
		James River, Va	6,667
			117,206
		Average	6,511

Hatfield gives for crushing strengths, yellow pine, 9516; white oak, 6068.

Rankine gives for crushing strengths, yellow pine, 5400; American white oak, 6000; English oak, 10,000.

C. Shaler Smith, according to Trautwine, gives as the crushing strength of yellow pine, 5000.

On the other hand, the following tables, which I have the kind permission of Col. Laidley to present to you, give the results of the tests on wooden posts and blocks that had been made at the Watertown arsenal, on the government testing machine, prior to these tests, and will be found given in full in his report of 1881:

YELLOW PINE—VERY STRAIGHT GRAINED, AND SEASONED ABOUT TWENTY YEARS.

Arsenal No.	Length—ins.	Form of section.	Dimension of section—ins.	Crushing strength per sq. in.	
573	20.4	Circular	10.2 diam.	6,676	
578	119.95	Rectangular	10.97x11	6,230	
579	119.9	Rectangular	10.96x10.96	6,552	
582	20	Rectangular	9 x 9	8,322	
583	16	Rectangular	8.02x 8.02	8,165	
584		Rectangular	4 x 4	7,394	
585	3	Rectangular	1.5 x 1.5	5,533	
586	6	Rectangular	3 x 3	8,644	
587	6	Rectangular	3 x 3	8,133	
588	3	Rectangular	1.5 x 1.5	8,329	
589	3	Rectangular	1.5 x 1.5	8,302	
590	3	Rectangular	1.5 x 1.5	6,355	All from one piece of timber.
				12)88,635	
				7,386	

From some yellow pine of very slow growth they obtained the following results:

591	14	Rectangular	4.6 x 4.6	9,947
592	17.2	Rectangular	4.6 x 4.6	10,250
593	19.1	Rectangular	5.3 x 5.3	7,820
				3)28,017
				9,339

They then tried some very green, and wet.

691	180	Open rect.	16 x13.65	3,070
692	180	Open rect.	16.2 x 7	2,795
714	180	Open rect.	17 x 8.75	3,180
				3)9,045
				3,015

Hence we have the following average values:

Straight grained and well seasoned (Arsen'l test).	7,386
Slow growth, straight grained and well seasoned (Arsenal test)	9,339
Very green and wet (Arsenal test)	3,015
Such yellow pine as was used in these tests	4,400
Rodman's results	7,913
C. Shaler Smith (according to Trautwine)	5,000

Why these enormous differences? Evidently the higher values are obtained from well seasoned and straight grained pieces, in other words, the differences are due to differences of quality, differences of seasoning, and differences of size of the pieces under test, for with small pieces we necessarily have less imperfections than with large ones. Moreover, it is plain that it is not safe to use as average values, the larger values.

In regard to white oak, the tests that had been made at the Watertown Arsenal previous to these were two in number, the specimens having been seasoning about 15 years, pieces 12 inches long, and 4x4 inches in section. The crushing strengths per square inch were respectively 7375 and 7010 pounds.

Of spruce, they had made quite a number of tests, as shown by the following table:

Arsenal numb'r.	Length—inches.	Form of section.	Dimension of section—ins.	Crushing str'gth per sq. in.
565	24	Rectangular	5⅜x5⅜	4,946
566	24	Rectangular	5⅜x5⅜	4,811
567	36	Rectangular	5⅜x5⅜	4,874
568	36	Rectangular	5⅜x5⅜	4,500
569	60	Rectangular	5⅜x5⅜	4,451
570	60	Rectangular	5⅜x6⅜	4,943
571	120	Rectangular	5⅜x5⅜	3,967
572	120	Rectangular	5⅜x5⅜	4,908
	60	Rectangular	5⅜x5⅜	5,275
	30	Rectangular	5⅜x5⅜	5,372
	15	Rectangular	5⅜x5⅜	5,754
577	121.2	Circular	12.4 diam.	4,681

Next, as to the tapering. Since posts of these sizes give way in the machine, by direct crushing, and not by bending, it necessarily follows that tapering a post is a source of weakness, and that we only have left the strength of the section at the smaller end. This will be more apparent when we look at the following comparative view of the strengths of tapered and of cylindrical posts of yellow pine; the latter having approximately the same diameters as the larger ends of the tapered ones.

COMPARISON OF THE CRUSHING STRENGTHS OF TAPERING AND CYLINDRICAL COLUMNS OF YELLOW PINE.

TAPERED COLUMNS.			CYLINDRICAL COLUMNS.	
Small diam't'r—ins.	Large diam't'r—ins.	Break'ng strength.	Diameter inches.	Breaking strength.
9.31	10.55	270,000	10.45	390.000
7.58	8.99	200,000	8.96	250,000
6.40	7.79	138,000	7.70	205,000

Hence the tapering of a 10.5 inch post so as to have a diameter at the small end of 9.31 inch was done at an expense of 120,000 pounds of strength, etc. Hence it is plain that tapering a column weakens it.

Moreover, since the wood is first cut in rectangular or square logs, it follows that the very turning it down to a circular form causes a loss of strength. I would, therefore, recommend that the logs be used in the square form in which they are sent to the market, and be not weakened by any reduction in size, and that

if this cannot be done and round columns are required, that they be not tapered, but have the same diameter throughout. The money saved by avoiding the turning and tapering could be much more profitably spent in improving the boring and the fitting at the ends.

In the second series of tests the four yellow pine blocks, and three of the oak blocks were first tested, and then yellow pine posts Nos. 4 and 3, the results being as already described, the details being recorded in the tables.

I decided next to make the attempt to imitate in part the conditions under which a post is used in practice, convinced, as I am, that, in order to prophesy with any certainty what will happen in the use of any piece, we must make our tests conform to these conditions. The first condition of practical usage to which I endeavored to conform was the use of an eccentric load, or a load whose resultant does not act at the centre of the end of the post. That this is the case in practice will be very evident when we consider the construction of an ordinary mill.

On the first floor we have a column, resting on a flat casting, on top of the column rests another flat casting, on which stands a pintle in the centre and the two adjacent floor beams on either side; above the pintle is the flat casting which supports the column of the second story, on top of which rests another flat casting, which in its turn supports another pintle in the centre and the two adjacent floor beams of the third story on either side.

Let us consider now, the column of the first story. All the load that is brought upon it from the stories, above the second, is brought through the pintle, and hence would be, if the fitting were perfect, applied at the middle; on the other hand, if the floor of the second story is unevenly loaded, one of the floor beams resting on the column having a heavier load than the other, the two loads due to the weight resting on the second story floor would be unequal, and hence the resultant load upon the column is not applied at the centre, but at some point outside of the centre.

My first attempt to imitate in a certain way this eccentric loading of a column was made with yellow pine post No. 2. The post rested against a flat casting as shown in the cut, back of this casting was placed a rectangular bar whose section was 1.36×1.1 in., the bar being placed in a horizontal position, with its centre at a depth of 2.33 in. below the central diameter of the column, the pressure being transmitted from the piston head of the machine to this bar, and thence to the column; the other end of the column having a full bearing at the other end of the machine. The pressure being now applied deflection of course set in, reaching 0.02 in. only, at 40,000 lbs., and constantly increasing with increased loads; at 100,000 the deflection became 0.1 in., at 150,000 0.15 in., at 200,000 it had already become 0.3 in. and now the plate had perceptibly ceased having a full bearing on the top of the post. At 250,000 the deflection had become 0.45 in., at 260,000 it was 0.5 and increased to 0.58., the column finally giving way at 265,000 by opening longitudinal cracks near the end loaded eccentrically, and deflecting upwards. This column had a sectional area of 76.7 square inches and, at the average value of the crushing strength per square inch of the yellow pine, viz., 4400 lbs., the column would have borne 337,500 lbs., thus we have a loss of strength of about 72,500 lbs. due solely to the eccentricity of the load, and as this eccentricity must undoubtedly take place when the column is in place in a mill, it is evident that a certain portion of the breaking strength, by no means inconsiderable, is to be deducted from this cause alone. This loss of strength was not at all as great as it would have been had the resultant pressure been applied along one horizontal line at the centre of the bar, the end of the column being, as it were, hinged at this line. In that case, theory would give us for the loss of strength 174,600 lbs. instead of 72,500. The remainder was taken up by the bending movement in the plate and in the bar, the action being evidently as follows: The eccentric pressure brought upon the bar an unequally distributed stress which caused the resultant to act at a point nearer the centre than 2.33 in., then the rigidity of this bar prevented the plate from turning around as it would about a knife edge, and caused a bending in the plate, so that a free bending of the end of the column was prevented, and there was a considerable bending moment taken up by the plate and bar, the pressure being thus, more evenly distributed on the column, than it would otherwise have been. It follows naturally, that the breaking strength would vary with the material of which the bar and plate were composed. In this case the plate was steel and the bar wrought iron.

White oak post No. 3 was next tried in a similar manner, the eccentricity of the centre of the bar being in this case 1.91 in. The deflection set in at 10,000 lbs., and increased rapidly till, when the load had reached 100,000 lbs., it had become 1.08 in.; this increased in 15 minutes to 1.7 in., and the post was then rapidly failing. This post had a sectional area of 50.92 square inches. At 3200 lbs. per square inch this would have borne with a uniformly distributed load 162,900 lbs.; there was thus a loss of 62,900 lbs. due to the eccentricity. Had the post been free to turn, or had it been resting against a knife edge at the centre of the bar instead of against the flat surface of the bar, theory would give a loss of 106,000 lbs. as against 62,900, thus leaving the breaking strength of the post 56,900 lbs.

In both the above cases it is plain that the breaking strength was considerably increased by the rigidity of the bar and plate. That there is a certain action of the same kind in practice from the rigidity of the pintle is also plain, and that the better fitted, and the larger the pintle the more will be the rigidity, and hence the greater the breaking strength. Of course it would be desirable to approximate as nearly as we can to the rigidity furnished by the pintle, or by different pintles, with different degrees of perfection in the fitting.

My attention was next called to the fact that the pintles in practice were likely to be a source of weakness, and hence I made two tests on columns with pintle ends. These tests, as well as those on the eccentric loading, hardly furnish more than general indications and suggestions for a systematic investigation that ought to be carried on in this regard. Thus the pintles in both cases were iron cylinders 4.35 in. diameter and 8.7 in. long, their ends being carefully turned in a lathe and made parallel to each other.

The two posts tried in this way were, 1st. White oak post No. 2, a very knotty, and poor stick. It remained with neither deflection, nor sliding nor rocking, on the pintles until the load reached 60,000 lbs., when motion took place near one of the pintles. This is shown in the right hand pair of columns of figures marked deflections, and it indicates the motion of the post at a point 1½ feet from its south end. This motion was not great, amounting only to 0.02 in. As the load increased, however, this motion rapidly increased, and at 180,000 lbs. a very considerable rocking on the pintles had already taken place, thus at the north end, the post had moved 0.09 in., at the south end 0.16 in. vertically and 0.07 in. horizontally, and it also had taken a very considerable deflection. At 190,000 lbs., where it failed, the rocking and deflection had both increased very considerably. If the 190,000 be divided by the area of the cross section we should obtain a breaking strength of only 2400 lbs. per square inch, which is far below any oak previously tested. This would make it appear that the pintles were a source of weakness, causing by their rocking a bending of the stick, and thus an unequal stress. Whether this is so or not, when the pintles are provided with perfectly parallel surfaces as they were in our case, is a matter for farther experiment to determine. The same post was subsequently tried with ends fixed in direction and then sawed apart, and one-half tested again with ends fixed in direction, but I do not feel authorized to draw any conclusions whatever from these latter tests, as the wood had been already subjected to severe stress. Nevertheless, the details are given in the table, and any one who feels so inclined can draw whatever conclusions he thinks proper.

The other post tried with pintle ends was a very straight grained stick of yellow pine (yellow pine post No. 1), and in this case there was hardly any rocking or sliding on the pintles, and the post was hardly weakened, if at all, by the pintle ends, the breaking being evidently effected by direct crushing and not by deflection.

Besides the above described tests two square columns of yellow pine were tested. These columns were such as were used in the exhibition building of the Charitable Mechanic Association, and are furnished with a yellow pine bolster, into which they are mortised. These two columns had been sent to the arsenal about the middle of last July, and had remained in a warm room since that time, so that they were in a much more advanced stage of seasoning than the other columns tested.

I first tested one of these, marked yellow pine post No. 4. It was placed directly in the machine without any eccentricity, resting at one end on the platform of the machine, and at the other on the bolster, such as is used in their building. The post was, as shown by the table, about 8.4 in. square. When the load had reached 20,000 lbs. the bolster began to give way, emitting snapping sounds, and continuing to do so, and gradually crushing more

and more as the load increased; very soon a wedge-shaped piece began to split off from one side, and the bearing of the post against the bolster was therefore on one side. The bolster was left in and allowed to become more and more broken up until the load reached 120,000 lbs., when the unequal pressure on the bolster caused the post to crack, the bolster itself being in the mutilated condition shown in the cut. The bolster was then taken out, the tenon on the post sawed off, the end of the post squared up, and the post itself tested with ends fixed in direction; it bore 375,000 lbs. pressure before breaking, when it gave way by the crushing of the fibres near one end. The pressure was then continued simply for the sake of marking the fracture more plainly, and during this continuance the post took a double flexure, giving way at the other end also and at the middle, the fracture at the middle showing both crushing and tearing of the fibres.

The above test shows how very bad a plan it is to use wooden bolsters instead of iron caps. The crushing strength in this case was 5400 lbs. per square inch.

I next tested the other yellow pine square post marked No. 5, first with the bolster and an eccentricity of loading. The bolster began as before to yield at about 20,000 lbs. and it was taken out when the load reached 60,000 lbs., and the tenon sawed off, the end squared up and the post itself tested with an eccentric load as before, the centre of the bar being 2.67 in. eccentric. The column yielded at 240,000 lbs., the behavior of the preceding posts being repeated. In almost all the tests the compressions under the different loads were measured with the view of determining the modulus of elasticity, or the ratio borne by the load per square inch to the compression per inch of length produced by that load, only those loads being used where equal increments of load give equal compressions.

In the case of the tapering posts, inasmuch as the section varied at different points, I used the middle section in computing the modulus of elasticity. By so doing, I obtained the following values:

YELLOW PINE.		WHITE OAK.	
No. 1	1,885,204	No. 1	1,222,222
2	1,631,035	2	1,633,987
3	2,087,347	3	1,5 4,389
4	2,204,085	4	1,748,817
	4)7,808,231		4)6,159,415
Average	1,95.,058	Average	1,539,854

On the other hand, in the second series of tests there could be no question as to what section to use, for they were of the same section throughout, and the following values were obtained:

YELLOW PINE BLOCKS.		WHITE OAK BLOCKS.	
No. 1	1,657,425	No. 2	1,.65,382
2	2,113,411	3	1,104,938
3	1,644,453	4	1,302,623
4	1,900,252		3)3,572,943
	4)7.645,571		
Average	1,911,393	Average	1,190,981

YELLOW PINE COLUMNS.

No. 3	2,160.882
4	2,081.3.1
	2)4,251,203
Average	2,125,602

We thus have as average values:

YELLOW PINE.		WHITE OAK.	
1st series	1,952,078	1st series	1,539,854
2d series blocks.	1,911,393	2d series blocks.	1,190,981
2d series posts	2,125,602		2)2,730,835
	3)5,989,053	Average	1,365,418
Average	1,996,351		

As to the discrepancy of the values deduced from the blocks and posts of yellow pine, it seems to me that it is probably due to the fact that the tests on posts and blocks were made in about the same length of time, and hence the intervals of time between the successive loads were about the same in the posts as in the blocks, and the posts may not have had sufficient time allowed to assume all the compression they would otherwise have assumed.

Now, as to instances of failure of mill columns in use, while I have made no special effort to ascertain them, I have heard of some from various causes; it is probable that were the matter fully investigated, more would be heard from. In one of the cases which have come to my attention dry rot was the cause of failure; in some others excessive and long continued dampness; and in another instance I was informed of the case of a burning mill five stories high, in which the floors fell in within twenty minutes after the alarm was sounded, and the whole building was in ruins inside of one hour. My informant thinks that the columns in this case were loaded nearly up to their breaking strength, and that then, a little charring so weakened them as to cause sudden failure. Without disputing his conclusions, since he was an eye witness of the occurrence, it seems to me that another cause must also have had a part in the transaction. Since the mill

was five stories in height, whenever the floor beams on one side of a vertical series of columns burned the set of columns was left in the condition of one very long column, and any initial deflection arising from imperfect fitting, would at once be very much increased by the eccentric loading, and the consequently long and jointed column would easily bend and fall. Now we need to know, just how far we can go safely in making a long column, and then either confine ourselves to a smaller number of stories, or else put in columns that will bear the greatest loads that can come upon them, together with their greatest eccentricity, and besides this we need to have very careful fitting between the cap plates and the pintles, and also, it seems to me exceedingly desirable, to know by actual test what is the result of just such imperfect fitting as we meet with in practice, and I believe it to be perfectly possible, by means of the power we have at our command, in the government testing machine, to thoroughly investigate this point, and hence to prescribe such conditions for the fitting as shall keep us within safe limits.

I will now proceed to sum up what, as it seems to me, are the conclusions that we may fairly draw from these experiments, in the light of the previous tests made at the arsenal, and the recommendations that these conclusions would lead me to make.

1. I should recommend that the longitudinal holes in wooden mill columns be bored from one end only, and that all posts be rejected in which the eccentricity at the other end is greater than a given small amount as three quarters of an inch. This recommendation is made in view of the facts that holes bored from the two ends are very liable not to meet in the middle, and hence not to allow a circulation of air, that if the hole becomes very eccentric the column is liable to be weakened, and also by the presence of two holes at the same section.

2. I should recommend that mill columns be not tapered, as the tapering is a source of weakness, the loss of strength in one of the cases tested amounting to about 120,000 lbs.

3. I should also recommend that square columns be used in mills instead of round ones, for the reason that the timber comes to the wharf in the form of square logs, and when the columns are made round, they are cut from the square form, and this cutting away of the wood is a source of weakness.

4. The strength of a column of hard pine or oak, with "flat ends," the load being uniformly distributed over the ends, and of the diameters tested, is practically independent of the length up to a length of twelve feet (how much further can only be decided by further experiment), such columns giving way practically by direct crushing, the deflection if any being as a rule very small and exerting no appreciable influence on the breaking strength.

5. The only exceptions to the above are found in cases where there is good reason for departure from the rule, as in the case of very imperfect wood or of very eccentric holes, but even there the influence of the deflection in reducing the strength is not nearly as great as has been generally supposed.

6. No formulæ founded on the generally received hypothesis, that the deflection exerts a very considerable influence on the breaking strength of such columns as those referred to represent correctly their breaking strength for all lengths and diameters.

7. For such columns as those referred to, the most correct rule for determining the breaking strength is to multiply the number of square inches in the section (the smaller section being used in the case of tapering columns) by the crushing strength per square inch, of the wood.

8. The crushing strength per square inch varies very considerably in specimens of different degrees of seasoning, also in large and small specimens.

9. The average crushing strength of wood is much less than has been supposed by many. That of some very highly seasoned hard pine was found at the arsenal to be 7386 lbs. For some hard pine of very slow growth and very highly seasoned an average crushing strength was found of 9339 lbs. For some very wet and green they found a crushing strength of 3015 lbs. For some yellow pine which had been seasoning about three months I found 5400 lbs. For average crushing strength of such posts as I tested, not thoroughly seasoned, and not very green I found about 4400 lbs., whereas in none of these cases did I obtain a greater result than about 4700 pounds. Hence it would be entirely unfair to assume a crushing strength of 8000 lbs. for yellow pine. For two specimens of white oak tried at the arsenal and very thoroughly seasoned, an average was obtained of about 7150 lbs., whereas for

such oak as was furnished me, which was very green and very knotty, I obtained an average of about 3200 pounds.

10. I would recommend the use of iron caps instead of wooden bolsters, as wood is very weak to resist crushing across the grain; and the wooden bolster will fail at a pressure far below that which the column is capable of resisting, and the unevenness of the pressure brought about by the bolster is so great as to sometimes crack the column at a pressure far below what it would otherwise sustain.

11. Any cause which operates to distribute the pressure on the ends unevenly, or to force its resultant out of centre, is a source of weakness, and brings about a very considerable deflection, which exerts an important influence in reducing the breaking strength.

12. As far as these experiments have gone, it appears that such pintles as were used in these tests, when the fitting is perfect, exert no influence upon the breaking strength of perfect and straight grained columns, but that they probably are a source of weakness in the case of imperfect and knotty wood, and especially in cases where there is an incipient deflection. Farther experiment is needed, however, to answer these questions fully.

13. I would also recommend that the horizontal holes connecting the longitudinal holes with the outside air be made in the iron cap, and not in the wood; this will prevent weakening of the post by the hole, and will prevent the closing of the hole by change, in moisture and other causes.

14. Another conclusion which I think, is very evident, is that the crushing strength of full size columns cannot be fairly inferred from tests made on columns no larger than five feet long and two inches on a side.

While it seems to me that the above conclusions can be drawn with certainty, the tests have furnished a large number of suggestions as to what ought to be done, and of opinions as to what would probably happen in certain cases of testing, but I should hardly feel willing to state mere opinions until they are verified or disproved by experiment. Nevertheless it seems to me that I have shown the great importance of carrying these tests farther, and making such a systematic inquiry into the strength of wooden mill columns that we may be able to predict with certainty what such columns will bear under all the usual conditions of loading. Such a systematized set of tests would necessarily cost more than the Boston Manufacturers' Mutual Fire Insurance Company would feel justified in expending, but would be only a trifle if taken up by two or three of our wealthy mill corporations and would far more than repay them, for the entire expense would be as nothing compared with the falling of a mill.

In such a set of tests properly carried out one should feel his way very carefully, and one result would naturally suggest another experiment; hence it would be very unwise to mark out beforehand the series of tests to be made, and not to allow modifications as circumstances might require. Nevertheless these tests have furnished such a quantity of suggestions that I can readily map out, in a general way, a series of tests that should be undertaken, and then modified as new suggestions arise.

1. All the sizes of columns ordinarily used in mills should be tested, both in the seasoned, and the unseasoned state, and both of oak and hard pine; or, rather, such a number of sizes should be tested that we may be able, from these, to infer with certainty, the strength of the remainder. We should thus ascertain whether, in any of the sizes used in mills, the deflection has any serious influence on the breaking strength, or whether such influence is confined to ratios of length to diameter greater than those used in mills. If the former is the case, the amount of influence of different lengths should be definitely ascertained. We could thus make out a table showing what are the breaking strengths of flat-ended mill columns where the load is uniformly distributed over the ends, and of such sizes as are commonly used.

2. All the different forms of pintles in common use should be tested to see what is their effect on the breaking strength of the columns, and in so doing, we should endeavor to imitate, as far as possible, all the imperfections of fitting used in practice. This, I believe, it is perfectly possible to do.

3. We should ascertain how the strength of a column with what, for want of a better term might be called rounded or pin ends, differs, if at all, from that of a column with ends fixed in direction. Hodgkinson claimed that the strength in these cases was very much decreased, in the longer columns to one-third what it was with flat ends. The effect of the tests on my mind in this regard is (to say the least) to throw a very grave doubt on such a conclusion, when the resultant of the load

passes through the centre of the column, and the question ought certainly to be settled.

4. We should then ascertain the effect of using ill fitting pintles and eccentric loads, thus trying to imitate, as far as possible, the conditions of practice.

5. We should examine the different kinds of wood used for mill columns, and ascertain its crushing strength both before and after it has been in use in a mill.

6. Another series of important experiments would be a set of tests to ascertain the effect of a long continued operation of loads less than the breaking load. These tests could be conveniently made, I believe, at the arsenal, though not in the machine; and the very fact of a column (1st series, yellow pine, No. 2), which broke at 190,000 pounds, acting for an hour, and which would probably have borne 200,000 or 210,000 pounds, if it had been applied at once, gives us good reason to suppose that, if the loads were left on for a month or a year, that a load considerably less than the instantaneous breaking load would produce rupture of the column, especially when changes of load occur.

Besides the above there are a great many other points that would present themselves during the course of the tests such as the determination of the limit of elasticity, if such a thing exists; the modulus of elasticity, etc., etc. Also, it might be desirable to test two columns in line with a pintle between them. Such information as that described (which would however be of immense value to the mills, and to constructors generally) would require a carefully conducted and systematic series of experiments on full size mill columns. The cost of such a set of tests is, of course, difficult to estimate exactly, and if the tests were not carefully planned and made, and the results were not carefully watched and correctly interpreted, it might involve a great deal of expense. But if the tests were properly conducted I should estimate the cost of a quite extensive series that would furnish a large amount of information somewhere in the neighborhood of $4000. This is a larger sum than an insurance company would feel justified in spending on such a matter, but if undertaken by two or three mill corporations they would not feel the expense, and, whenever a question arose, as to the safety of adding weight on their columns, or of putting in new columns, they would have some information on the subject that could be depended upon.

I will say that Mr. Atkinson has authorized me to carry these tests a little farther, and that I shall therefore touch upon one or two of the matters mentioned above, but all that I can do, while keeping within such limits of expense as he can authorize me to make, will be to obtain a few more suggestions which will be far from giving us all the information on the subject, that we need. I would therefore urge upon our mill corporations the importance of having such a series of tests made while the matter is fresh, and not to wait until some disaster calls more forcible attention to it.

I cannot close without acknowledging specially the assistance and suggestions I have received from Mr. Howard, the skilful operator of the machine, and also a great many suggestions which I have either received directly, or have been led to think of, by some remarks made casually by other people who have taken an interest in these experiments.

In conclusion. I desire to emphasize very strongly, the great importance of conforming, in our testing, to the conditions under which the piece under test is used in practice; and bearing in mind that tests made under any different conditions only furnish us certain data, by means of which, with the use of our judgment, to determine the behavior of the piece in practice; and that just as far as we have fallen short of conforming the conditions of the test to the conditions of practice, just so far are our data upon which to form our judgment insufficient.

I will add that the results of these tests have already been put into practical use in a large and important construction.

Since the above was written, an opportunity presented itself for testing some old columns, and Mr. Atkinson having authorized me to to spend a little more money, but not at all enough to make any one of the investigations complete, I have used it to obtain a few more facts, which contain, as I believe, a number of useful suggestions.

The old columns were all of oak, and came from three different mills, which I will call respectively mills Nos. 1, 2, and 3, No. 2 being the Pacific Mills at Lawrence. The posts that were received from mill No. 1, seven in number, had been in service about six and a half years, and were removed because they were deemed unsuitable. They were all about 12 feet long, about 6¾ inches in diameter at

the larger end, and 5¾ to 6 inches in diameter at the smaller end. They were all bored and the boring was excellent, as I was unable to find one where there was not a hole clear through. The load they had sustained is estimated by one of the gentlemen connected with the mill at about 10,600 pounds per column, besides the weight of the snow in winter. They were provided at the top with a maple cap surmounted by an oak base on which rested the next column above, or the roof timbers. Of these columns three, viz., Nos. 1914, 1915 and 1916, were tested between the platforms of the machine, the ends being brought to an even bearing. The remainder, viz., Nos. 1917, 1918, 1931 and 1932 had the maple cap and oak base interposed between the column and the platforms of the machine, the ends, of course, not being brought to an even bearing. It is also to be observed, that all the old columns were painted, the defects being thereby partially concealed. The results are given in the tables annexed, and, by dividing the breaking weight by the area of the smallest section in each case, we find as crushing strengths per square inch the following:

No.	Lbs.	No.	Lbs.
1914	4902	1917	2943
1915	6052	1918	3263
1916	4682	1931	4223
		1932	3550

It is to be observed that No. 1914 was not straight; No. 1915 had but few apparent defects; No. 1916 was not straight, and had some large season cracks, one especially being very large; No. 1917 did not appear to have a great many knots, and those where it failed were not very large; No. 1918 was not straight, and, furthermore, had its larger end decayed; Nos. 1931 and 1932 had a number of small knots, but did not appear to have any very large ones. As to deflections induced by the load, we see from the tables that this was almost inappreciable in the case of the second; in the first and third it reached about .75 inches; in the fourth about .4 inches, while in the last three it exceeded one inch very considerably. It is to be observed that in only one case does the crushing strength per square inch reach 6000 pounds, and also that, in the case of the last four, where the maple caps and oak bases were used, and the ends were not squared up, the strength averages less than in the case of the first three.

Those columns, ten in number, that are marked as coming from mill No. 2, were taken out of the worsted department of the Pacific Mills, at Lawrence, where they are making some alterations. Six of these came from the first floor of the mill, and are marked A, B, C, D, E and F, respectively, and the remaining four were taken out of the second story of the mill and are marked respectively G, H, I and J. All were about 14 feet long, the first six having each a diameter of about 10.5 inches, and the last four of about 9.5 inches. Of the first six, the first four were tested simply between the platforms of the machine, the ends being brought to an even bearing in one case only, viz., in the case of D. E and F were tested with an iron base plate at one end, and an iron cap and pintle at the other, the pintle being 19.6 inches long, and having for cross section a hollow rectangle 8.45×5 inches outside, and 7.1×3.75 inches inside, the base, cap and pintle being those that had been used in the mill with some one of these columns. The crushing strengths per square inch, obtained by dividing the breaking strength by the area of the section in each case, are as follows:

A.....4265, ends not squared.
B.....3580, " "
C.....4934, " "
D.....4604, ends squared.
E.....4362, with pintle.
F..... 4823, " "

Of these posts A was not straight; B had a winding grain, season cracks, and was not straight; C was quite knotty and appeared shaky near the failure; D, E and F appeared to be tolerably free from defects.

The posts G, H, I and J were taken from the second floor of the mill, and are about 14 feet long and 9.5 inches in diameter. The first three were placed simply between the platforms of the machine, the ends being in no case brought to an even bearing, and the fourth, or J, was tested with an iron base-plate and pintle at one end, and an iron cap and pintle at the other. The results are given in the tables, and from them, if we divide the breaking weight in each case by the area of the section, we obtain, as crushing strengths per square inch, the following:

G.....4,881, ends not squared.
H .....3,433, " " "
I.....3,981, " " "
J.....3,266, with pintles.

I will add that these four posts appeared quite defective, having a good many knots, and being more or less bent, and, in the case of J, the post was gouged out to a depth of about ⅛ of an inch for a length of about 20 inches near the base. In the case of H, the post

towards the end of the test took what, for want of a better term, I have described as a triple flexure, i.e., it had three points of inflection, one of which was in the neighborhood of the middle where the deflections were measured.

All these posts from the Pacific Mills had been in service about twenty-five years, and, if we assume 50 pounds per square foot as the weight on the roof and 60 pounds per square foot as the weight on the floor, we should obtain as the load that had been supported on each of the first six from 46,400 to 53.650 pounds, and as the load on each of the last four from 36,800 to 42,550 pounds.

From mill No. 3 I had one old oak column, of which I know nothing about the time it had been in service, nor the load it had borne. It was placed simply between the platforms of the machine and showed a crushing strength of 6147 pounds per square inch.

The above eighteen are all the old oak columns that were tested. It will be noticed that in two cases we obtain a strength a little over 6000 pounds per square inch. but that n no other case does the strength exceed 5000 pounds, and that in one case in mill No. 1 when the maple caps were used, it fell as low as 2943 pounds per square inch.

The next set of posts consisted of two white oak posts and one white oak block left untested last November. The smaller of these posts, marked in the tables No. 4, second series, was tested squarely in the platforms of the machine, the ends being brought to an even bearing. It had a crushing strength of 3219 pounds per square inch. The block left untested broke with 4450 pounds per square inch. The post was, however, very poor and the block very good. Both had been kept in the storehouse since last November. The remaining post of this lot had a diameter of 10.95 inches and this was a poor stick. It was tested with the load eccentric 2¾ inches, the load being applied along a single line by the use of the castings shown in the sketch, the rigidity due to the bar used in making the eccentric tests last November being thus avoided. The result was, as would naturally be expected, a great reduction of strength, as the post, if 3000 pounds per square inch were assumed as its crushing strength, would have borne 276.480 pounds, whereas the actual load under which failure took place was 170,000 pounds.

The remaining posts and blocks were of yellow pine furnished by Messrs Stetson & Moseley, and were each four in number. Nos. 1 and 2 were square, No. 1 being Savannah timber, dock seasoned, and No. 2 Brunswick timber, also dock seasoned. The corresponding blocks were of the same kind of timber, but I cannot assert that they were cut from the same piece. In the case of the round ones the corresponding blocks were cut from the same pieces of timber, and bored. One of these columns was 14 feet long, Port Royal timber, seasoned on the wharf, the other was 12 feet long, Port Royal timber, and dock seasoned. The first was tested between the platforms of the machine, and bore 4254 pounds per square inch, the deflection before fracture being very small; the block which was sawed from the end of the post bore 4892 pounds per square inch, the post in this case having a great many season cracks.

The other round post was 12 feet long and was tested with one end flat, the load being centrally applied along a single line, by means of the castings shown in the cut. It bore 4662 pounds per square inch, while the block sawed from its end bore only 3604 pounds per square inch, the block containing a knot where failure took place. The square posts were tested, one with the load eccentrically applied along a single line, and the other with a pintle with the ends not parallel. The results are given in the tables, together with the crushing strengths of the corresponding blocks.

Perhaps the most important result of this set of tests is the fact that these old oak columns which had been in use gave crushing strengths whose average is far below 6000 or 7000 pounds per square inch, and hence that, while such crushing strengths and even higher ones can be obtained by means of well seasoned and perfect pieces, this would not answer for an average crushing strength for such oak as has been in these mills. Another matter worthy of attention is the fact that these old oak columns were frequently very brittle, and often split on breaking. I was unable to obtain any old yellow pine columns.

The experiments with eccentric loads combined with a bearing along a single line, thus avoiding the rigidity of the bar used in the other case, showed, as was to be expected, a much greater reduction of strength. The ill fitting obtained in those posts from mill No. 1 where the maple caps were used appears to cause a loss of strength, but in the cases of

the pintles and eccentric loads we need a large number of tests, and those made can only serve as special cases. They furnish us but little indication in the case of the pintles, and still continue to exhibit a large reduction of strength in the case of the eccentric loads, and a greater reduction the less the rigidity.

In concluding I can only reiterate what I have already said, in regard to the importance to our mill corporations of having a thorough investigation made of these matters involving complete series of tests, in which the conditions of practice are approximated to as nearly as possible, and I would urge the importance of the same kind of investigation to those railroad companies that use wooden bridges. If formulæ could thus be obtained for certain cases we should be very fortunate, but I look rather for the making of tables, such as I described on page 13 of this report, and certainly if formulæ could be obtained we should expect to find different ones for every different mode of fixing the ends.

Before closing, I must state that I have recently had some correspondence with Mr. C. Shaler Smith, and that I have been requested by him to state that the formula given for yellow pine columns in Trautwine's hand book as Mr. Smith's formula, was intended, as I understand from his letter, to meet the case of such ill fitting joints and other imperfections as occur in practice, and not for perfectly even bearings. I will also add that Col. Laidley, of the Watertown arsenal, is now carrying on a set of tests of a large number of white and yellow pine columns, all tested between the platforms of the machine with even bearings. This series of tests cannot fail to furnish some very valuable information, and it would be very desirable if it could be followed up by other extensive series of tests such as I have already mentioned.

Respectfully submitted,

GAETANO LANZA.

Boston, June 1, 1882.

This report formed the subject of two communications, by the author, to the Society of Arts, of the Massachusetts Institute of Technology; one on December 8, 1881, and the other on May 11, 1882, and of a paper read before the American Society of Mechanical Engineers on April 21, 1882.

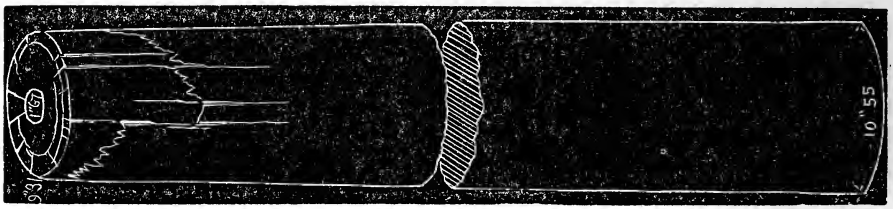
TABLES OF TESTS.

FIRST SERIES.

Yellow Pine, No. 1.

Total length.....12 feet 0.15 inches.
Gauged " .....130 inches.
Good post free from knots.
Weight.....320 pounds.

Diameter of larger end.....10.55 inches.
" " middle .....10.65 "
" " smaller end.....9.31 "
" " core.....1.67 "
Maximum sectional area.....85.22 square inches
Minimum " " .....65.9 " "

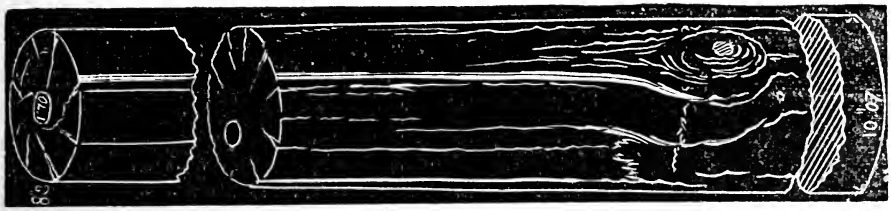


Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Deflection. a. Hor.	a. Ver.	b. Hor.	b. Ver.	c. Hor.	c. Ver.	Remarks
5,000	.8182	.....	.57	1.11	.50	1.05	.43	.99	
10,000	.8150	.0032	.....	.....	.....	.....	.....	.....	
20,000	.8055	.0127	.....	.....	.....	.....	.....	.....	Ants appear.
30,000	.7966	.0216	.....	.....	.....	.....	.....	.....	
40,000	.7876	.0306	.....	.....	.....	.....	.....	.....	
50,000	.7782	.0400	.....	.....	.....	.....	.....	.....	
60,000	.7692	.0490	.....	.....	.....	.....	.....	.....	
70,000	.7605	.0577	.....	.....	.....	.....	.....	.....	
80,000	.7506	.0676	.55	1.11	.45	1.04	.38	.98	
90,000	.7420	.0762	.....	.....	.....	.....	.....	.....	
100,000	.7330	.0852	.54	1.10	.44	1.04	.36	.98	
100,000	.7330	.0352	.....	.....	.....	.....	.....	.....	5 minutes' rest.
5,000	.8162	.0020	.....	.....	.....	.....	.....	.....	
110,000	.7240	.0942	.....	.....	.....	.....	.....	.....	
120,000	.7150	.1032	.52	1.10	.44	1.04	.36	.98	{Rested 15 hours.
108,100	.7200	.0982	.....	.....	.....	.....	.....	.....	{Load on in morning.
120,000	.7095	.1087	.54	1.10	.43	1.03	.36	.97	
5,000	.8110	.0072	.....	.....	.....	.....	.....	.....	
5,000	.8116	.0066	.....	.....	.....	.....	.....	.....	5 minutes' rest.
130,000	.7012	.1170	.....	.....	.....	.....	.....	.....	
140,000	.6920	.1262	.....	.....	.....	.....	.....	.....	
150,000	.6820	.1352	.....	.....	.....	.....	.....	.....	
160,000	.6740	.1442	.....	.....	.....	.....	.....	.....	
170,000	.6645	.1537	.....	.....	.....	.....	.....	.....	
180,100	.6552	.1630	.51	1.09	.41	1.02	.34	.96	
190,000	.6455	.1727	.....	.....	.....	.....	.....	.....	
200,000	.6360	.1822	.....	.....	.....	.....	.....	.....	
210,000	.6262	.1920	.....	.....	.....	.....	.....	.....	
220,000	.6160	.2022	.50	1.08	.40	1.01	.31	.95	
220,000	.6150	.2032	.....	.....	.....	.....	.....	.....	
5,000	.8080	.0102	.....	.....	.....	.....	.....	.....	
5,000	.8086	.0096	.....	.....	.....	.....	.....	.....	
220,000	.6124	.2058	.....	.....	.....	.....	.....	.....	
230,000	.6035	.2147	.....	.....	.....	.....	.....	.....	
230,000	.6026	.2156	.....	.....	.....	.....	.....	.....	5 minutes' rest.
240,000	.5930	.2252	.....	.....	.....	.....	.....	.....	
250,000	.5830	.2352	.....	.....	.....	.....	.....	.....	
260,000	.5720	.2462	.47	1.03	.35	.96	.28	.91	
260,000	.5635	.2547	.....	.....	.....	.....	.....	.....	5 minutes' rest.
270,000	.5450	.2732	.....	.....	.....	.....	.....	.....	
270,000	.5190	.2992	.....	.....	.....	.....	.....	.....	5 minutes' rest.
270,000	.....	.....	.....	.....	.....	.....	.....	.....	7 minutes' rest, then failed rapidly.

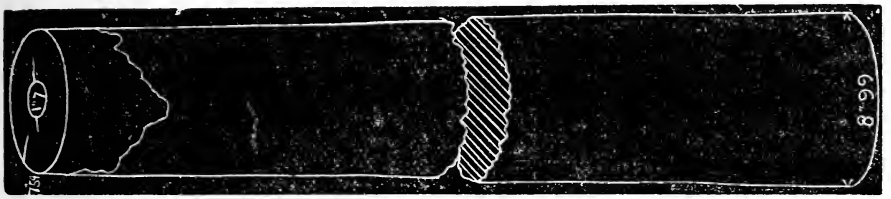
Failed at smaller end by the fibres crumpling 1 inch to 8 inches from end. Horizontal deflections show column convex on side opposite heart.

Deflections marked *c* were measured at the middle, those marked *b* at a distance of 12 inches from the middle, and those marked *a* at a distance of 24 inches from the middle, both towards the smaller end.

Yellow Pine, No. 2.



Yellow Pine, No. 3.



Yellow Pine, No. 2.

Total length.....12 feet 0.2 inches.
Gauged length..... 13.0 "
Weight of post.....235 pounds.
Diameter of larger end.....10.07 inches.
" " middle..... .....9.71 "
" " smaller end.....8.30 "
" " core..... 1.79 "
Maximum sectional area.....77 square inches.
Minimum " "..... 51.9 " "

Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.8502	.....	.94	1.52	
10,000	.8446	.0056	.....	.....	
20,000	.8322	.0180	.....	.....	
30,000	.8200	.0302	.....	.....	
40,000	.8065	.0437	.....	.....	
50,000	.7935	.0567	.....	.....	
60,000	.7805	.0697	.....	.....	
60,000	.7792	.0710	.94	1.52	After resting.
70,000	.7670	.0832	.....	.....	
80,000	.7533	.0972	.....	.....	
90,000	.7450	.1102	.....	.....	
100,000	.7260	.1242	.....	.....	Season crack opened wider.
110,000	.7122	.1380	.....	.....	
120,000	.6982	.1520	.94	1.52	
120,000	.6960	.1542	.....	.....	5 minutes' rest.
130,000	.6830	.1672	.....	.....	
140,000	.6690	.1812	.....	.....	
150, 00	.6545	.1957	.94	1.52	
150,000	.6515	.1987	.....	.....	3 minutes' rest.
160,000	.6375	.2127	.....	.....	
170,000	.6215	.2287	.....	.....	
180,000	.6070	.2132	.95	1.50	
180,000	.6032	.2470	.....	.....	3 minutes' rest.
190,000	.5880	.2622	.....	.....	
190,000	.5750	.2752	.....	.....	8 minutes' rest.
190.000	.....	.....	.....	.....	Ultim'te strength

The load 190,000 lbs. was maintained on this post one hour. Yielding began and continued from the first application, slowly at first, but increasing in rapidity towards the close of the experiment. The behavior of the column confirming our observation of other posts, that a load which at first is sustained without apparent permanent injury may be sufficient to finally cripple the column. The post failed at a large knot in the middle.

Post sawed apart after fracture. Core bored out of centre about 1¾ inch eccentric, on opposite sides from failure at knot.

Yellow Pine, No. 3.

Total length.....12 feet 0.13 inches.
Gauged " .....13.0 "
Weight.....211 pounds.
Diameter of larger end..... .....8.99 inches.
" " middle..... .....8.88 "
" " smaller end.....7.54 "
" " core..... .....1.7 "
Maximum sectional area.....61.2 square inches.
Minimum " " .....42.5 " "

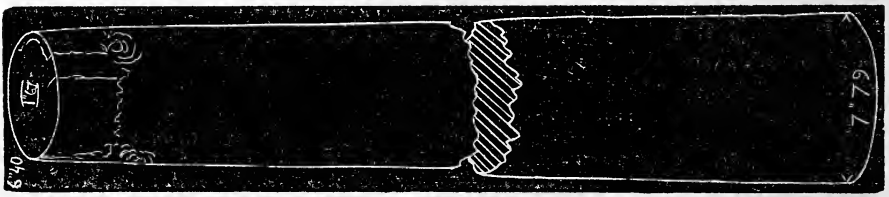
Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.7976	.....	1.40	1.93	
10,000	.7930	.0046	.....	.....	
20,000	.7820	.0156	.....	.....	
30,000	.7700	.0276	.....	.....	
40,000	.7580	.0396	.....	.....	
50,000	.7462	.0514	1.42	1.94	
50,000	.74 5	.0521	.....	.....	2 minutes' rest.
60,000	.7333	.0643	.....	.....	
70,000	. 216	.0760	.....	.....	
80,000	.7095	.0881	.....	.....	
90,000	.6963	.1013	.....	.....	
100,000	.6835	.1141	1.42	1.94	
100,000	.6832	.1144	.....	.....	3 minutes' rest.
110,000	.6756	.1270	.....	.....	
120,000	.6576	.1440	.....	.....	
130,000	.6455	.1521	1.43	1.95	
140,000	.6316	.1660	.....	.....	Crack heard.
140,000	.6305	.1671	.....	.....	1 minutes' rest.
140,000	.6300	.1676	.....	.....	4 minutes' rest.
150,000	.6172	.1844	.....	.....	
150,000	.6160	.1816	.....	.....	2½ minutes' rest.
150,000	.6155	.1829	.....	.....	4 minutes' rest.
160,000	.6025	.1951	.....	.....	Rested 15 hours.
132,000	.6128	.1850	.....	.....	Load on in morning.
160,000	.5865	.2111	.....	.....	
170,000	.5735	.2241	.....	.....	
180,000	.5602	.2374	.....	.....	
190,000	.5432	.2544	1.44	1.96	
190,000	.5352	.2624	.....	.....	3 minutes' rest.
200,000	.5165	.811	.....	.....	
200,000	.4930	.3046	.....	.....	3 minutes' rest.
200,000	.....	.....	.....	.....	6 min. rest then failed rapidly.

Failed by fibres crumpling 4 in. to 8 in. from smaller end, obliquely around post; also fibres crumpled 32 in. from smaller end in vicinity of small knot.

Yellow Pine, No. 4.

Total length.....12 feet 0.2 inches.
Gauged " .....130 "
Sectional area minimum.....30 square "
" " maximum.....45.6 " "

Weight in pounds.....164
Diameter of larger end.....7.79 inches.
" " middle.....7.8 "
" " smaller end.....6.4 "
" " core.....1.67 "



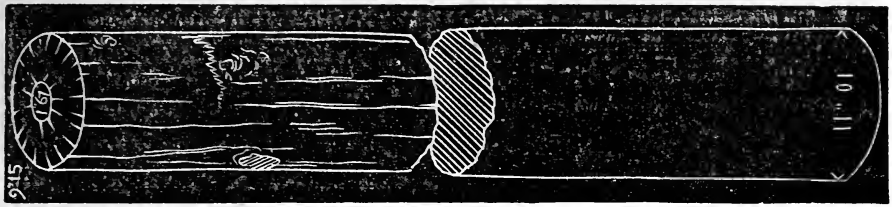
Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Deflection Readings. a. Hor.	a. Ver.	b. Hor.	b. Ver.	c. Hor.	c. Ver.	Remarks.
5,000	.6612	.....	2.03	2.59	1.89	2.44	1.84	2.49	
10,000	.6522	.0090							
5,000	.6605	.0007							
20,000	.6346	.0246	2.03	2.57	1.83	2.44	1.82	2.39	Slight cracking sound.
5,000	.6596	.0016							
30,000	.6240	.0412							
5,000	.6590	.0022							
40,000	.6035	.0577	2.03	2.58	1.86	2.44	1.82	2.40	
5,000	.6580	.0032							
50,000	.5830	.0732							
60,000	.5570	.0742							Sustained 5 minutes.
5,000	.6572	.0040							
60,000	.5725	.0887	2.02	2.53	1.88	2.45	1.82	2.40	
54,000	.5712	.0900							After 5 minutes. Rested 15 hours.
52,000	.5780	.0832	2.02	2.60	1.87	2.45	1.81	2.43	The load running down to 52,000 lbs.
5,000	.6510	.0102	2.02	2.58	1.87	2.44	1.82	2.40	
61,000	.5502	.0950							
71,000	.5505	.1107							
5,000	.6515	.0097							
81,000	.5350	.1262	2.00	2.60	1.85	2.46	1.80	2.42	
80,000	.5342	.1270							5 minutes' rest.
80,000	.5342	.1270							13 minutes' rest.
5,000	.6505	.0106	2.02	2.58	1.88	2.45	1.82	2.40	
90,000	.5192	.1420							
5,000	.6505	.0106							
100,000	.5050	.1562	2.00	2.62	1.85	2.47	1.80	2.43	
100,000	.5040	.1572							5 minutes' rest.
5,000	.6510	.0102							
5,000	.6516	.0096							4 minutes' rest.
110,000	.4880	.1732							
5,000	.6512	.0109							
120,000	.4716	.1896							
120,000	.4702	.1910							5 minutes' rest.
5,000	.6506	.0106							
5,000	.6516	.0096							5 minutes' rest.
130,000	.4552	.2060							
130,000	.4526	.2086	1.92	2.66	1.80	2.52	1.75	2.47	5 minutes' rest.
130,000	.4520	.2092							15 minutes' rest.
5,000	.6496	.0116	2.00	2.61	1.86	2.47	1.80	2.42	
5,000	.6512	.0100							5 minutes' rest.
138,000	.....	.....							Ultimate strength.

Failed at knots about 4 ins. from the end. The fibres crumpling outside of the gauged length.

Deflections marked *c* were measured at the middle, those marked *b* at a distance of 12 inches from the middle, and those marked *a* at a distance of 24 inches from the middle, both towards the smaller end.

White Oak, No. 1.

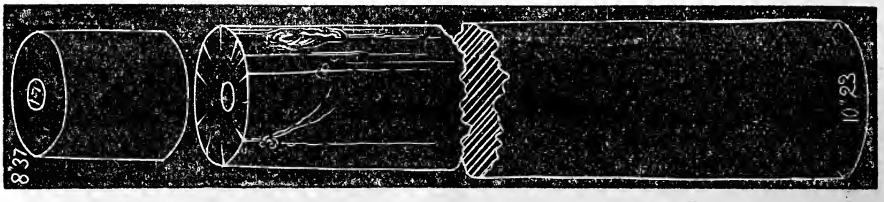
Total length.....12 feet 0.17 inches.
Gauged " .....130 inches.
Weight.....395 pounds.
Diameter of larger end.....11.01 inches.
Diameter of middle.....10.15 "
" " smaller end.....9.15 "
" " core.....1.67 "
Maximum sectional area.....93. square inches.
Minimum " " .....63.2 " "



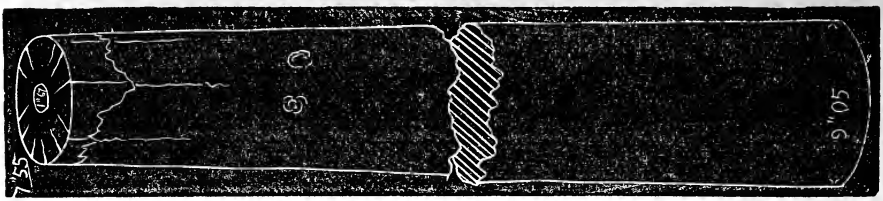
Load applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Deflection. a. Hor.	a. Ver.	b. Hor.	b. Ver.	c. Hor.	c. Ver.	Remarks.
5,000	.7700	.....	.73	1.40	.72	1.30	.67	1.26	
10,000	.7710	.0010	.....	.....	.....	.....	.....	.....	
20,000	.7655	.0045	.....	.....	.....	.....	.....	.....	
30,000	.7630	.0070	.....	.....	.....	.....	.....	.....	
40,000	.7625	.0075	.....	.....	.....	.....	.....	.....	
50,000	.7600	.0100	.77	1.38	.73	1.29	.68	1.24	
5,000	.7676	.0024	.....	.....	.....	.....	.....	.....	
60,000	.6955	.0745	.....	.....	.....	.....	.....	.....	
65,000	.6898	.0802	.....	.....	.....	.....	.....	.....	Sustained 1 hour.
5,000	.7630	.0070	.....	.....	.....	.....	.....	.....	
70,000	.6780	.0920	.....	.....	.....	.....	.....	.....	
5,000	.7640	.0090	.....	.....	.....	.....	.....	.....	
80,000	.6646	.1054	.....	.....	.....	.....	.....	.....	
5,000	.7630	.0070	.....	.....	.....	.....	.....	.....	
90,000	.6500	.1200	.....	.....	.....	.....	.....	.....	
5,000	.7635	.0065	.....	.....	.....	.....	.....	.....	
100,000	.6392	.1308	.76	1.37	.72	1.27	.68	1.23	
100,000	.6330	.1370	.....	.....	.....	.....	.....	.....	5 minutes' rest.
100,000	.6312	.1388	.....	.....	.....	.....	.....	.....	10 minutes' rest.
5,000	.7600	.0100	.....	.....	.....	.....	.....	.....	
5,000	.7625	.0075	.....	.....	.....	.....	.....	.....	5 minutes' rest.
110,000	.6190	.1510	.....	.....	.....	.....	.....	.....	
110,000	.6152	.1548	.....	.....	.....	.....	.....	.....	5 minutes' rest.
120,000	.6005	.1695	.75	1.35	.72	1.26	.68	1.22	
120,000	.5970	.1730	.....	.....	.....	.....	.....	.....	5 minutes' rest.
120,000	.5816	.1884	.....	.....	.....	.....	.....	.....	
120,000	.5775	.1925	.....	.....	.....	.....	.....	.....	5 minutes' rest.
120,000	.5750	.1950	.....	.....	.....	.....	.....	.....	10 minutes' rest.
140,000	.5585	.2115	.75	1.31	.70	1.24	.67	1.20	
140,000	.5538	.2161	.....	.....	.....	.....	.....	.....	5 minutes' rest.
150,000	.5370	.2330	.....	.....	.....	.....	.....	.....	
150,000	.5302	.2398	.....	.....	.....	.....	.....	.....	5 minutes' rest.
150,000	.5240	.2460	.....	.....	.....	.....	.....	.....	10 minutes' rest.
160,000	.5065	.2635	.74	1.33	.70	1.23	.65	1.18	
160,000	.4982	.2718	.....	.....	.....	.....	.....	.....	5 minutes' rest.
170,000	.4760	.2940	.....	.....	.....	.....	.....	.....	
180,000	.4490	.3210	.75	1.28	.71	1.17	.65	1.13	
180,000	.4075	.3625	.....	.....	.....	.....	.....	.....	5 minutes' rest.
180,000	.3540	.4160	.....	.....	.....	.....	.....	.....	15 minutes' rest.
190,000	.3065	.4635	.83	1.09	.77	.97	.70	.93	Ultimate strength.

Failed at knots 12 in. and 15 in. from smaller end. After the post had yielded under 190,000 lbs. and continued to fail under that load, pressure was suddenly applied, increasing the load to 195,000 lbs., the column yielding all the time.

White Oak, No. 2.



White Oak. No. 3.



White Oak, No. 2.

Total length.....12 feet 0.2 inches.
Gauged " .....130 "
Weight.....325 pounds.
Diameter of larger end.....10.23 inches.
" " middle.....9.4 "
" " smaller end.....8.37 "
" " core.....1.67 "
Maximum sectional area.....79.8 square inches.
Minimum sectional area.....72.8 " "

Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.8532	.....	1.02	1.55	
10,000	.8470	.0062	.....	.....	
20,000	.8350	.0182	.....	.....	
30,000	.8232	.0300	.....	.....	
40,000	.8116	.0416	.....	.....	
50,000	.7995	.0537	1.00	1.55	
60,000	.7872	.0660	.....	.....	
70,000	.7750	.0782	.....	.....	
80,000	.7622	.0910	.....	.....	
90,000	.7490	.1042	.....	.....	
100,000	.7356	.1176	.98	1.55	
100,000	.7346	.1186	.....	.....	2 minutes' rest.
110,000	.7332	.1200	.....	.....	5 minutes' rest.
110,000	.7202	.1330	.....	.....	
120,000	.7063	.1436	.....	.....	
130,000	.6930	.1602	.....	.....	
140,000	.6775	.1756	.....	.....	
150,000	.6625	.1906	.96	1.55	
160,000	.6609	.1922	.....	.....	3 minutes' rest.
160,000	.6460	.2072	.....	.....	
170,000	.6276	.2256	.....	.....	
180,000	.6110	.2422	.95	1.56	
180,000	.6015	.2517	.....	.....	3 minutes' rest.
190,000	.5762	.2770	.....	.....	
200,000	.5485	.3047	.....	.....	
200,000	.5112	.3420	.....	.....	3 minutes' rest.
210,000	.4750	.3782	.46	1.84	5 minutes' rest.
200,000	.3770	.4762	.....	.....	Ultim. strength.

Column failed by deflection at middle, following apparently the direction of bending that the stick had originally before it was turned into a column, fibres crumpled in vicinity of knots. Sawed apart after test at middle, heart at centre. Core bored 1 in. eccentric at middle of post. The post bent concave on side with the core.

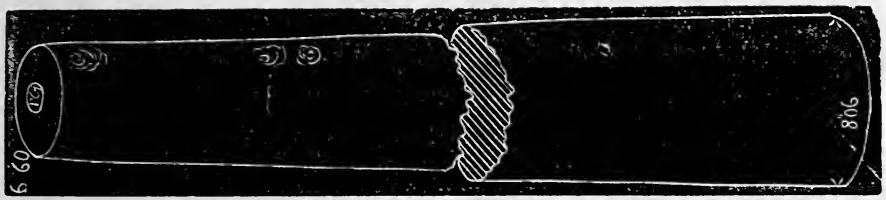
Oak, No. 3.

Total length.....12 feet 0.2 inches.
Gauged " .....130 "
Weight of post.....289 pounds.
Diameter of larger end.....9.05 inches.
" " middle.....8.75 "
" " smaller end.....7.55 "
" " core.....1.67 "
Maximum sectional area.....62.1 square inches.
Minimum " ".....52.6 " "

Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.7932	.....	1.44	1.92	
10,000	.7845	.0087	.....	.....	
20,000	.7685	.0247	.....	.....	
30,000	.7525	.0407	.....	.....	
40,000	.7365	.0567	.....	.....	
50,000	.7192	.0740	1.44	1.90	
50,000	.7170	.0762	.....	.....	3 minutes' rest.
60,000	.7005	.0927	.....	.....	about 8 min. rest.
70,000	.6833	.1097	.....	.....	
80,000	.6682	.1247	.....	.....	
90,000	.6485	.1447	.....	.....	
100,000	.6285	.1647	1.40	1.89	
100,000	.6262	.1670	.....	.....	3 minutes' rest.
110,000	.6090	.1842	.....	.....	
120,000	.5875	.2057	.....	.....	
130,000	.5660	.2272	.....	.....	
140,000	.5430	.2502	.....	.....	
150,000	.5050	.2882	1.43	1.83	
150,000	.4752	.3180	.....	.....	about 5 min. rest.
170,000	.4205	.3727	.....	.....	10 min. rest.
150,000	.3765	.4167	.....	.....	15 min. rest.
160,000	.....	.....	.....	.....	Ultim'te strength.

Failed at knots about 24 inches from smaller end bending concave on the side of the knots.

Oak, No. 4.



Oak, No. 4.

Total length.....12 feet 0.2 inches.
Gauged length.....130 inches.
Gauging rod screwed to post.

Three 24 inch sections A, B and C laid off and round headed screws put in post gauging the compression in these sections with Vernier callipers.

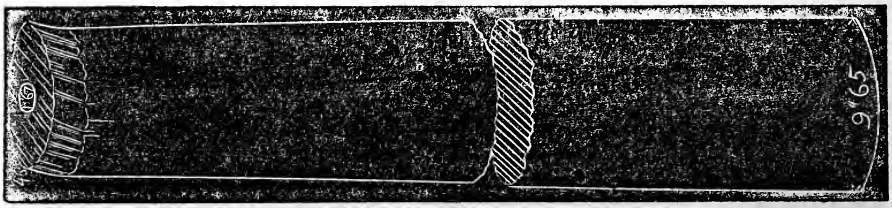
Horizontal and vertical gaugings to the nearest 1.100 inches taken at the points a, b, c, d, and e, 12 inches apart, c being at the middle of the length of the post, and a and b being toward the smaller end.

Weight in pounds.....215.
Distance of heart from centre large end 1.21 in. about
" " " " " small end.....0.89 inches.
Diameter of larger end.....3.06 "
" " middle.....7.79 "
" " smaller end.....6.69 "
" " core.....1.67 ",
Minimum sectional area.....32 square inches.
Maximum " " 88

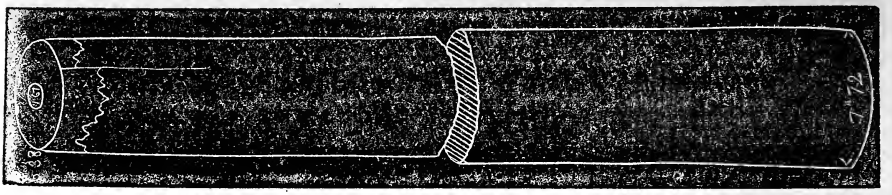
Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Gauge A.	Gauge B	Gauge C.	Deflections—Readings in Inches. a. Hor.	a. Ver.	b. Hor.	b. Ver.	c. Hor.	c. Ver.	d. Hor.	d. Ver.	e. Hor.	e. Ver.	Remarks
5,000	.4382	.....	.201	.194	.181	2.00	2.71	1.96	2.66	1.92	2.57	1.82	2.47	1.80	2.40	
10,000	4275	.0107	.196	.192	.178	.....	.....	.....	.....	1.92	2.57	.....	.....	.....	.....	
5,000	.4365	.0016	.198	.194	.180	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
20,000	.4046	.0.95	.192	.189	.175	.....	.....	.....	.....	1.90	2.56	.....	.....	.....	.....	
5,000	.4370	.0012	.198	.194	.180½	.....	.....	.....	.....	1.92	2.57	.....	.....	.....	.....	
30,000	.3892	.0490	.189	.185	.172	.....	.....	.....	.....	1.92	2.56	.....	.....	.....	.....	
5,000	.4370	.0012	.....	.....	.....	.....	.....	.....	.....	1.91	2.57	.....	.....	.....	.....	
40,000	.3700	.0682	.....	.....	.....	.....	.....	.....	.....	1.92	2.56	.....	.....	.....	.....	
5,000	.4362	.0 20	.197	.195	.181	.....	.....	.....	.....	1.91	2.57	.....	.....	.....	.....	
50,000	.3500	.0882	.....	.....	.....	.....	.....	.....	.....	1.92	2.56	.....	.....	.....	.....	
5,000	.4365	.0017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
60,000	.3300	.1082	.....	.....	.....	.....	.....	.....	.....	1.93	2.56	.....	.....	.....	.....	
5,000	.4332	.0030	.197	.193	.181	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
70,000	.3105	.1277	.....	.....	.....	.....	.....	.....	.....	1.93	2.55	.....	.....	.....	.....	
5,000	.4370	.0032	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
80,000	.2870	.1512	.....	.....	.....	.....	.....	.....	.....	1.94	2.54	.....	.....	.....	.....	
5,000	.4330	.0052	.195	.192	.180	.....	.....	.....	.....	1.92	2.57	.....	.....	.....	.....	
90,000	.2636	.1746	.....	.....	.....	.....	.....	.....	.....	1.96	2.54	.....	.....	.....	.....	
5,000	.4290	.0092	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
5,000	.4322	.0060	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5 min. rest.
100,000	.2336	.2016	.....	.....	.....	.....	.....	.....	.....	1.99	2.52	.....	.....	.....	.....	
100,000	.2320	.2062	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4 min. rest.
100,000	.2265	.2117	.....	.....	.....	2.13	2.62	2.10	2.56	2.03	2.50	1.94	2.40	1.90	2.35	8 min. rest.
100,000	.2180	.2202	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16 min. rest.
100,000	.2116	.2266	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24 min. rest.
100,000	.2080	.2302	.....	.....	.....	2.23	2.59	2.18	2.53	2.12	2.46	.....	.....	.....	.....	28 min. rest.
100,000	.2043	.2336	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32 min. rest.
100,000	.2012	.2370	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36 min. rest.
5,000	.4089	.0302	.....	.....	.....	2.06	2.48	2.02	2.63	1.96	2.54	.....	.....	.....	.....	
5,000	.4165	.0217	.....	.....	.....	2.05	2.69	2.02	2.63	1.95	2.54	.....	.....	.....	.....	5 min. rest.
5,000	.4185	.0197	.185	.191	.178	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10 min. rest.
5,000	.4196	.0186	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15 min. rest.
110,000	.1775	.....	.....	.....	.....	2.02	2.32	2.83	2.27	2.64	2.23	.....	.....	.....	.....	

Sustained 110,000 lbs. momentarily, but yielded immediately, and failed at the knot shown by sketch.

Whitewood, No. 1.



Whitewood, No. 2.



Whitewood, No. 1.

Total length.....12 feet 0.2 inches.
Gauged " .....t.....100 "
Weight.....142 pounds.
Diameter of larger end.....9.65 inches.
" " middle.....9.61 "
" " smaller end.....8.46 "
" " core.....1.67 "
Maximum sectional area.....70.9 square inches.
Minimum " " .....54. " "
Stick does not contain the heart.

Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.8316	.....	.99	1.58	
10,000	.8200	.0065	.....	.....	
20,000	.8100	.0216	.....	.....	
30,000	.7950	.0365	.....	.....	
40,000	.7800	.0516	1.02	1.55	
40,000	.7795	.0521	.....	.....	2 minutes' rest.
50,000	.7646	.0670	.....	.....	
60,000	.7492	.0824	1.02	1.55	
60,000	.7492	.0824	.....	.....	2 minutes' rest.
70,000	.7340	.0976	.....	.....	
80,000	.7190	.1126	.....	.....	
90,000	.7040	.1276	.....	.....	
100,000	.6885	.1431	1.04	1.58	
100,000	.6876	.1440	.....	.....	2 minutes' rest.
110,000	.6722	.1594	.....	.....	
120,000	.6570	.1746	.....	.....	
120,000	.6556	.1760	.....	.....	2 minutes' rest.
120,000	.6550	.1766	.....	.....	3½ minutes' rest.
130,000	.6 90	.1926	.....	.....	
140,000	.6240	.2076	1.04	1.60	
140,000	.6226	.2090	.....	.....	
150,000	.6030	.2256	.....	.....	
160,000	.5895	.2421	1.04	1.60	
160,000	.5870	.2446	.....	.....	2½ minutes' rest.
170,000	.5825	.2491	.....	.....	5 minutes' rest.
180,000	.5795	.2521	.....	.....	7½ minutes' rest.
180,000	.5772	.2544	.....	.....	10 minutes' rest.
170,000	.5512	.2704	.....	.....	
190,000	.5420	.2896	1.04	1.60	Ultimate strength.

Sustained 180,000 lbs. about 5 minutes, yielding all the time, then failed suddenly at the smaller end, the fibres bending and crumpling.

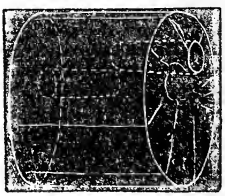
Whitewood, No. 2.

Total length.....11 feet 11.63 inches.
Gauged " .....t.....100 "
Weight.....109 pounds.
Diameter of larger end.....7.72 inches.
" " middle.....7. 0 "
" " smaller ends.....6. 8 "
" " core.....1.67 "
Maximum sectional area.....46.6 square inches
Minimum " " .....19.8 " "
Post cut out of large stick; does not contain the heart.

Loads applied. Pounds.	Gauge reading. Inches.	Compression. Inches.	Middle Deflection Readings. Hor.	Middle Deflection Readings. Ver.	Remarks.
5,000	.8162	.....	2.15	2.52	
10,000	.7970	.0192	.....	.....	
20,000	.7670	.0492	2.15	2.47	
20,000	.7660	.0502	.....	.....	2 minutes' rest.
5,000	.8125	.0037	.....	.....	
30,000	.7380	.0782	2.15	2.45	
30,000	.7376	.0786	.....	.....	2 minutes' rest.
40,000	.7095	.1067	.....	.....	
50,000	.6810	.1352	.....	.....	
60,000	.6520	.1632	2..8	2.45	
60,000	.6530	.1632	.....	.....	2 minutes' rest.
70,000	.6235	.1927	.....	.....	
80,000	.5860	.2302	2..2	2.55	
80,000	.5650	.2512	.....	.....	2 minutes' rest. Ultimate strength

Failed by fibres crumbling at smaller end.

Yellow Pine Post, No. 2.



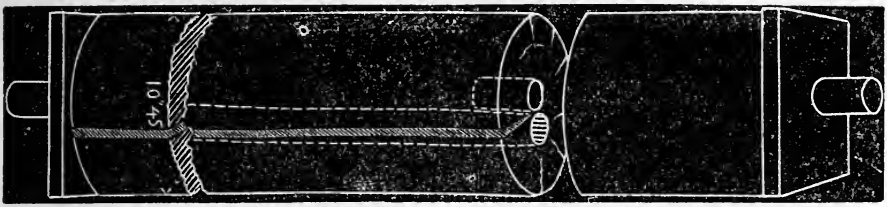
The above cut exhibits the eccentricity of the holes in Pine Post No. 2.

SECOND SERIES.

Yellow Pine Post No. 1.

Weight.....332 pounds.
Length.....144 inches.
Diameter (outside).....10.45 inches.

Diameter of core.....1.60 inches.
Sectional area.....83.75 sq. ins.
Counterweight at middle.....150 lbs.
Tested with pintle ends.



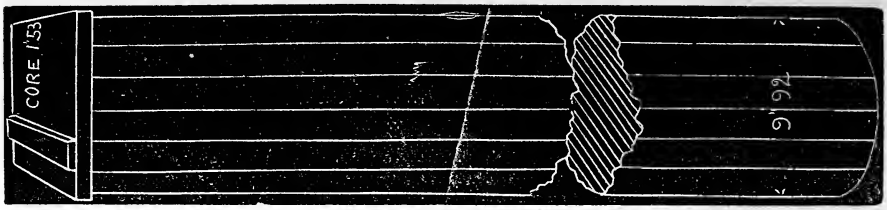
Loads applied. Pounds.	Deflections.						Remarks.
	1½ ft. from N. end.		Centre.		1½ ft. from S. end.		
	Horizon.	Vertical.	Horizon.	Vertical.	Horizon.	Vertical.	
5,000	0	0	0	0	0	0	
10,000	0	0	0	0	0	0	
20,000	0	0	0	0	0	0	
30,000	0	0	0	0	0	0	
40,000	0	0	0	0	0	0	
50,000	0	0	0	0	0	0	
60,000	0	0	0	0	0	0	
70,000	0	0	0	0	0	0	
80,000	0	0	0	0	0	0	
90,000	0	0	0	6	0	0	
100,000	0	0	0	0	0	0	
110,000	0	0	0	0	0	0	
120,000	0	0	0	0	0	0	
130,000	0	0	0	0	0	0	
140,000	0	0	0	0	0	0	
150,000	0	0	0	—.01	0	0	
160,000	0	0	0	—.01	0	0	
170,000	0	0	—.01	—.01	0	0	
180,000	0	0	—.01	—.01	0	0	
190,000	0	0	—.01	—.01	0	0	
200,000	0	0	—.02	—.01	0	0	
210,000	0	0	—.02	—.01	0	0	
220,000	0	—.01	—.02	—.01	0	0	
230,000	0	—.01	—.02	—.01	0	0	
240,000	0	—.01	—.02	—.01	0	0	
250,000	0	—.01	—.02	—.01	0	—.01	
260,000	0	—.01	—.02	—.01	0	—.01	
270,000	0	—.01	—.02	—.01	0	—.01	
280,000	0	—.03	—.03	—.02	0	—.01	
290,000	0	—.03	—.03	—.02	0	—.01	
300,000	0	—.03	—.03	—.02	0	—.01	
310,000	0	—.03	—.03	—.02	0	—.01	
320,000	0	—.04	—.03	—.04	0	—.01	
330,000	—.01	—.04	—.04	—.04	0	—.01	
330,000	—.01	—.04	—.03	—.04	0	—.01	
340,000	—.01	—.05	—.03	—.05	0	—.01	
350,000	—.01	—.05	—.03	—.05	0	—.01	
360,000	—.01	—.05	—.03	—.05	0	—.02	
370,000	—.01	—.05	—.03	—.05	0	—.02	
380,000	—.01	—.05	—.03	—.05	0	—.02	
390,000	—.01	—.06	0	—.05	0	—.02	
390,000	+.07	—.05	.12	.04	—.02	+.03	10 minutes' rest.
390.000	.....	.....	.....	.....	.....	.....	Ult. str'gth=4657 lbs. per sq. in.

Post failed by deflecting horizontally, opening season cracks and crumpling the fibres.

Yellow Pine Post, No. 2.

Weight.....320 pounds.
Total length.....143.27 inches.
Gauged length.....140 "
Diameter (outside).....9.92 inches.
Diameter of core.....1.53 "
Sectional area.....75.45 sq. inches.

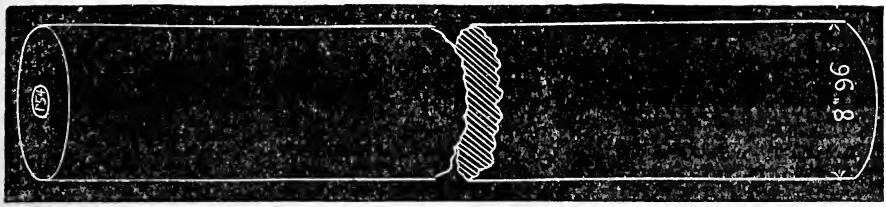
Counterweight at middle.....150 pounds.
Thickness of steel plate.....1.5 inches.
Thickness of iron rod.....1.1 inches.
Width of iron rod.....1.36 inches.
Loaded eccentrically as shown by the cut.
Eccentricity.....2⅛ inches.



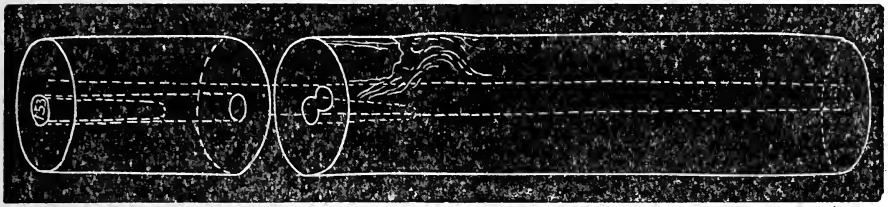
Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Deflections. Centre. Horizon.	Deflections. Centre. Vertical.	Deflections. 2½ feet from centre, near eccentric end. Horizon.	Deflections. 2½ feet from centre, near eccentric end. Vertical.	Remarks.
5,000	0		0	0	0	0	
10,000	.0010		0	0	0	0	
20,000	.0045		0	0	0	0	
30,000	.0087		0	0	0	0	
40,000	.0131		0	.02	0	.02	
50,000	.0170		0	.04	0	.04	
5,000		0	0	0	0	0	
60,000	.0201		0	.05	0	.05	
70,000	.0250		0	.08	0	.08	
80,000	.0290		0	.10	0	.10	
90,000	.0332		0	.10	0	.10	
100,000	.0375		0	.10	0	.10	
5,000		0	0	0	0	0	
110,000	.0412		0	.11	0	.11	
120,000	.0450		.02	.12	.02	.12	
130,000	.0490		.03	.13	.03	.13	
140,000	.0525		.04	.14	.04	.14	
150,000	.0562		.05	.15	.05	.15	
5,000		0	0	0	0	0	
160,000	.0595		.06	.16	.06	.16	
170,000	.0630		.06	.17	.06	.17	
180,000	.0665		.07	.20	.07	.20	
190,000	.0696		.08	.21	.08	.21	
200,000	.0727		.08	.25	.08	.30	1½ inch steel plate leaves bearing at top of post.
5,000		0	0	0	0	0	
210,000	.0748		.08	.25	.08	.33	
220,000	.0775		.08	.27	.08	.36	
230,000	.0770			.30		.37	6 minutes' rest.
230,000	.0800		.10	.31	.10	.40	
230,000	.0795		.10	.32	.10	.41	5 minutes' rest.
5,000		0	0	0	0	0	micrometer removed.
240,000			.10	.31	.10	.40	
240,000			.10	.35	.10	.42	5 minutes' rest.
250,000			.10	.38	.10	.45	
260,000			.10	.42	.10	.50	
270,000			.10	.50	.10	.58	5 minutes' rest.
265,000							Ultimate strength.

The maximum load was sustained momentarily, yielding rapidly taking place. It is very probable that had the load, 260,000 lbs., been carried a few minutes longer, that failure would have taken place under that load.
Post failed by opening longitudinal cracks at end loaded, eccentrically deflecting at the time upwards.

Yellow Pine Post. No. 3.



Yellow Pine Post, No. 4.



Yellow Pine Post, No. 3.

Weight.....249 pounds.
Total length.....143.2 inches.
Gauged length.....140 "
Diameter (outside).....8.96 inches.
Diameter of core.....1.54 "
Sectional area.....61.2 sq. inches.
Counterweighted at middle.....126 pounds.

Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Deflections. Hor.	Deflections. Ver.	Remarks
5,000	)		0	0	
10,000	.0076		0	0	
20,000	.0168		0	0	
30,000	.0219		0	0	
40,000	.0375		0	0	
50,000	.0480		0	0	
5,000		0	0	0	
60,000	.0582		0	0	
70,000	.0689		0	0	
80,000	.0791		0	0	
90,000	.0900		0	0	
100,000	.1000		0	—.02	
5,000		.0010	0	0	
110,000	.1110		0	—.02	
120,000	.1220		0	—.03	
130,000	.1330		0	—.02	
140,000	.1440		0	—.05	
150,000	.1550		0	—.05	
5,000		.0019	0	0	
160,000	.1655		.02	—.06	
160,000	.1669		.02	—.06	
170,000	.1776		.03	—.07	
180,000	.1885		.04	—.07	
180,000	.1895		.05	—.07	5 minutes' rest.
190,000	.2000		.06	—.07	
200,000	.2110		.07	—.09	
200,000	.2140		.07	—.09	5 minutes' rest.
5,000		.0060	0	0	
210,000	.2260		.08	—.10	
210,000	.2268		.08	—.10	5 minutes' rest.
220,000	.2380		.09	—.10	
230,000	.2500		.09	—.10	
230,000	.2548		.10	—.11	5 minutes' rest.
240,000	.2660		.10	—.11	
250,000	.2796		.10	—.13	
250,000	.2920		.10	—.13	5 minutes' rest.
250,000					Ult. str'th = 4055 lbs. per sq. in.

Rapid failure took place after sustaining the maximum load about 8 minutes, crumpling the fibres at a distance of 3 to 4 feet from end.

Post sawed apart after the test, showing the holes bored out of centre at the middle of the post.

Yellow Pine Post, No. 4.

Weight.....180 pounds
Total length.....143.7 inches.
Gauged length.....140 "
Diameter (outside).....7.7 inches.
Diameter of core.....1.53 "
Sectional area.....44.72 sq. inches.

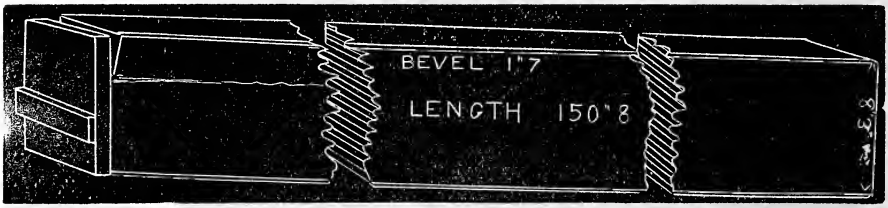
Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Centre Deflections. Hor.	Centre Deflections. Ver.	Remarks.
5,000	0		0	0	
10,000	.0070		0	0	
20,000	.0222		0	0	
30,000	.0365		0	0	
40,000	.0515		0	0	
50,000	.0665		0	—.02	
5,000		0	0	0	
60,000	.0815		0	—.02	
70,000	.0965		0	—.03	
80,000	.1111		0	—.03	
90,000	.1265		0	—.04	
100,000	.1423		0	—.06	
5,000		.0020	0	0	
110,000	.1560		0	—.06	Counter weigt'd at middle with 88 lbs.
120,000	.1715		0	—.07	
130,000	.1875		0	—.08	
140,000	.2022		0	—.09	
150,000	.2192		0	—.10	
5,000		.0035	0	0	
160,000	.2350		0	—.10	
160,000	.2384		0	—.11	5 minutes' rest.
170,000	.2540		0	—.12	
170,000	.2569		0	—.13	5 minutes' rest.
180,000	.2724		0	—.14	
180,000	.2770		0	—.15	5 minutes' rest.
190,000	.2938		0	—.17	
190,000	.3006		0	—.18	5 minutes' rest.
200,000	.3184		0	—.20	
200,000	.3300		0	—.22	5 minutes' rest.
205,000	.3418		0	—.24	
205,000	.3590		0	—.28	5 minutes' rest.
205,000					Ult. strength.

After sustaining the maximum load 8 minutes failure occurred very rapidly by deflecting downward and sideways. Splitting and crumpling of the fibres taking place at the middle of the post. After the test the post was sawed apart near the middle, showing the core not in the centre, and the holes which were bored from each end did not coincide.

Yellow Pine Post, No. 5.

Weight.....298 pounds.
Length.....150.8 inches.
Sectional area.....63.1 square inch.
Loaded eccentrically at end with wooden bolster.

Same plate and rod used as with yellow pine post No. 2.
Eccentricity (to middle of wrought iron bar.....2.07 ins
Counter weighted.....100 pounds



Loads applied. Pounds.	Deflections. Middle. Horizon.	Middle. Vertical.	2½ ft. from middle. Horizon.	2½ ft. from middle. Vertical.	Thickness of bolster. Ins.	Remarks
5,000	0	0	0	0	.....	
10,000	0	0	0	0	.....	
20,000	0	0	0	0	9.39	
30,000	0	0	0	0	9.39	
40,000	0	+.04	0	+.04	9.34	
50,000	0	.13	0	.15	9.22	
60,000	0	.22	0	.32	9.00	Yield still continuing.

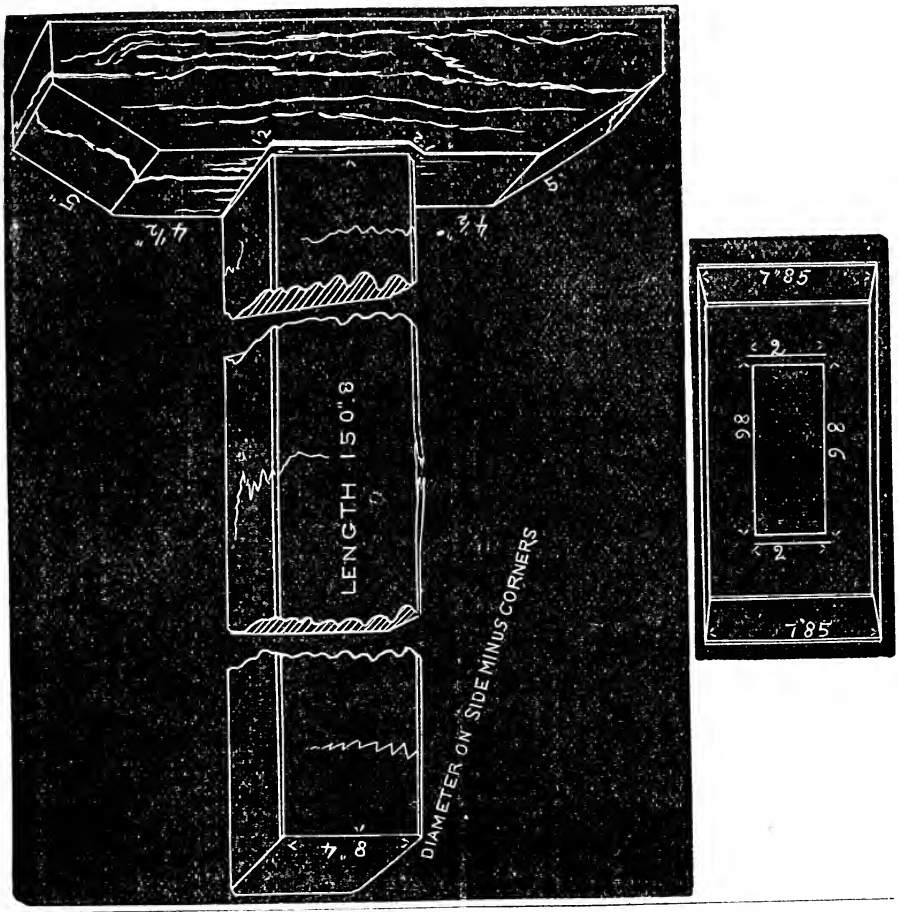
Wooden bolster removed and ends carefully squared. Tested with same eccentricity 2.07 as before. Arrangements of plate the same as on yellow pine post No. 2.

Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Deflections. Centre. Horizon.	Centre. Vertical.	2½ feet from centre. Horizon.	2½ feet from centre. Vertical.	Remarks
5,000	0	.....	0	0	0	0	
10,000	.0010	.....	0	0	0	0	
20,000	.0039	.....	0	0	0	0	
30,000	.0072	.....	0	+.03	0	+.03	
40,000	.0110	.....	0	.06	0	.06	
50,000	.0149	.....	0	.07	0	.07	
60,000	.0190	.....	+.03	.10	+.03	.10	
70,000	.0228	.....	.03	.12	.03	.12	
80,000	.0265	.....	.03	.14	.03	.15	
90,000	.0304	.....	.03	.16	.03	.18	
100,000	.0340	.....	.03	.18	.03	.20	
5,000	.....	0	0	0	0	0	
110,000	.0380	.....	.03	.20	.03	.24	
120,000	.0412	.....	.03	.24	.03	.26	
130,000	.0447	.....	.03	.26	.03	.31	
140,000	.0475	.....	.03	.30	.03	.35	
150,000	.0500	.....	.05	.33	.05	.40	
5,000	.....	0	0	0	0	0	
160,000	.0511	.....	.05	.37	.05	.45	
170,000	.0520	.....	.05	.41	.05	.50	
180,000	.0520	.....	.05	.46	.05	.56	
190,000	.0520	.....	.05	.54	.05	.62	
200,000	.0511	.....	.05	.60	.05	.68	
5,000	.....	−.0010	0	.03	0	.10	
210,000	.....	.....	.05	.68	.05	.80	
220,000	.....	.....	.05	.74	.05	.88	
230,000	.....	.....	.07	.83	.07	1.00	
240,000	.....	.....	.....	.95	.....	1.12	
240,000	.....	.....	.....	1.00	.....	1.20	Ultimate strength.
5,000	.....	.....	.....	.11	.....	.25	

Post failed by opening longitudinal cracks at the end loaded eccentrically.

Yellow Pine Post and Bolster No. 4.

Weight.....218 pounds.
Gauged length .....140 inches.
Sectional area.....68.8 square inches.
Bearing of post on bolster not a good one.
Post concave on upper side counter weighted.....150 lbs.



Loads applied. Pounds.	Compression. Inches.	Centre Deflections. Horizon.	Centre Deflections. Vertical.	Thickness of bolster. Ins.	Remarks.
5,000	0	0	0	.....	
10,000	.0008	0	0	.....	
20,000	.0010	—.03	+.02	7.62	Snapping sounds proceed from bolster.
30,000	.0090	—.04	+.03	7.60	
40,000	.0202	—.04	+.03	7.57	Post reaches a full bearing on bolster
50,000	.0329	—.05	0	7.55	
5,000	0	0	0	7.62	
60,000	.0450	—.05	0	7.54	
65,000	.0528	—.05	—.01	7.53	
70,000	.0595	—.05	—.01	7.51	
75,000	.0678	—.05	—.01	7.50	
80,000	.0769	—.05	—.01	7.41	
85,000	.0840	—.05	—.01	7.33	
90,000	.0900	0	—.03	7.25	
95,000	.0960	0	—.04	7.18	
100,000	.1025	0	—.05	7.02	
105,000	.....	.....	.....	6.80	End with bolster has moved over laterally ¼ inch owing to yielding of bolster.
120,000	.....	.....	.....	.....	

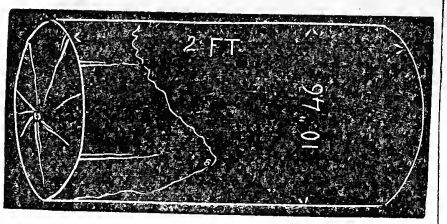
Maximum load on the post while the bolster was in was 120,000 lbs. = 1744 lbs. per square inch. Under this load a crack at end A was enlarged giving evidence that failure of the post was increased. The bolster in the meantime had become thoroughly cracked owing to the unequal distribution of the load on the bolster from imperfect workmanship; slight cracks followed the first snapping sounds heard at 20,000 lbs. compression. The cracks gradually developed as the loads were increased and the side nearest the heart of the bolster sliding off. This behavior of the bolster is thought to account for the variations in the horizontal and vertical deflections observed.

Post taken from machine and bolster removed. Post cut off 1½ inches at end and squared. Total length now 149.35 inches. Ultimate strength 375,000 lbs. = 5451 lbs. per square inch. Column failed about 15 inches from lower end by crumpling the fibres and causing slight deflection in a diagonal direction. Strains were continued developing failure of fibres at the middle of the post and rapidly increasing the diagonal deflection.

Yellow Pine Block, No. 1.

Total length.....24.125 inches.
Gauged length.....18 inches.
Diameter.....10.46 inches.
Sectional area.....85.9 sq. inches.
Weight.....62 pounds.

This block was in wet condition, the juice running out when driving the screws for measuring points.

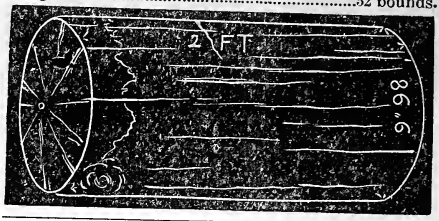


Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	.....	
10,000	.0002	.....	
50,000	.0052	.....	
5,000	.....	0	
80,000	.0090	.....	
100,000	.0111	.....	
5,000	.....	0	
120,000	.0137	.....	
150,000	.0179	.....	
5,000	.....	0	
170,000	.0200	.....	
200,000	.0238	.....	
5,000	.....	0	
210,000	.0250	.....	
220,000	.0265	.....	
230,000	.0276	.....	
240,000	.0288	.....	
250,000	.0300	.....	
5,000	.....	0	
260,000	.0315	.....	
270,000	.0329	.....	
280,000	.0341	.....	
290,000	.0355	.....	
300,000	.0380	.....	
5,000	.....	0	Rested 1 hour.
310,000	.0385	.....	
320,000	.0398	.....	
330,000	.0412	.....	
340,000	.0429	.....	
350,000	.0446	.....	
5,000	.....	.0010	
360,000	.0468	.....	
370,000	.0510	.....	
380,000	.0620	.....	Ult. strength = 4424 lbs. per sq. in.

Failure by crumpling fibres and opening longitudinal crack. Failed rapidly as soon as the maximum strain was reached.

Yellow Pine Block, No. 2.

Length.....24 inches.
Gauged length.....18 inches.
Diameter.....9.98 inches.
Sectional area.....78.23 sq. inches.
Weight.....52 pounds.

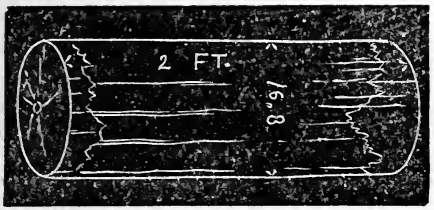


Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	.....	
10,000	0	.....	
20,000	0	.....	
30,000	.0006	.....	
5,000	.....	0	
40,000	.0014	.....	
50,000	.0020	.....	
5,000	.....	0	
60,000	.0030	.....	
70,000	.0038	.....	
80,000	.0049	.....	
90,000	.0057	.....	
100,000	.0068	.....	
5,000	.....	0	
110,000	.0080	.....	
120,000	.0088	.....	
130,000	.0098	.....	
140,000	.0108	.....	
150,000	.0119	.....	
5,000	.....	0	
160,000	.0128	.....	
170,000	.0140	.....	
180,000	.0150	.....	
190,000	.0161	.....	
200,000	.0171	.....	
5,000	.....	0	
210,000	.0185	.....	
220,000	.0195	.....	
230,000	.0206	.....	
240,000	.0219	.....	
250,000	.0230	.....	
5,000	.....	.0007	
260,000	.0243	.....	
270,000	.0253	.....	
280,000	.0268	.....	
290,000	.0282	.....	
300,000	.0295	.....	
5,000	.....	.0009	
310,000	.0320	.....	
320,000	.0336	.....	
330,000	.0340	.....	
340,000	.0358	.....	
350,000	.0430	.....	
5,000	.....	.0031	
360,000	.0498	.....	
338,000	.....	.....	Ult. strength = 4704 lbs. per sq. inch.

Loads applied gradually. When the maximum strain was nearly reached, the fibres failed rapidly, crumpling at the middle and also at the end, in the vicinity of knots, the greatest disturbance of the fibres taking place at the middle of the block.

Yellow Pine Block, No. 3.

Total length.....24⅛ inches.
Diameter.....8.91 inches.
Sectional area.....62.35 sq. inches.
Gauged length.....18 inches
Weight.....41 pounds.



Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	.....	This block it is supposed came off the end of Post No. 3.
10,000	.0007	.....	
20,000	.0030	.....	
30,000	.0051	.....	
40,000	.0070	.....	
50,000	.0089	.....	
5,000	.....	0	
60,000	.0105	.....	
70,000	.0121	.....	
80,000	.0139	.....	
90,000	.0154	.....	
100,000	.0170	....	
5,000	.....	.0035	
110,000	.0184	.....	
120,000	.0200	.....	
130,000	.0 16	....	
140,000	.0231	.....	
150,000	.0247	.....	
5,000	.....	.0010	
160,000	.0260	.....	
170,000	.0277	.....	
180,000	.0290	.....	
190,000	.0308	.....	
200,000	.0322	.....	
5,000	.....	.0024	
210,000	.0339	.....	
220,000	.0356	.....	
230,000	.0373	.....	
240,000	.0400	.....	
250,000	.0423	.....	
250,000	.0443	.....	After 5 mins.' rest.
250,000	.0450	.....	After 10 mins.' rest.
250,000	.0450	.....	After 15 mins.' rest.
260,000	.0460	.....	
270,000	.0465	.....	
270,000	.0467	....	After 5 mins.' rest.
270,000	.....	.....	{Ultimate strength =4330 lbs. per sq. in

Fibres crumpled at the ends.

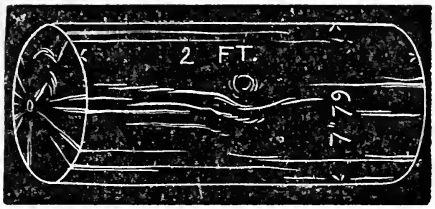
Lines of fracture followed in directions at 45° to axis of block extending from the ends, to 4 ins. from the ends. The middle parts of each end 3 ins. diameter were unsupported; the compression platforms of the testing machine having holes of that diameter.

Also one end of the block was concave, taking a bearing from the outer diameter 2½ inches wide. Failure began gradually, and after sustaining the maximum load about 8 minutes, failure took place rapidly.

Knots in the vicinity of the fractures may have influenced the manner and location of failure.

Yellow Pine Block, No. 4.

Length.....24 inch.
Gauged Length.....18 inch.
Diameter.....7.79 inch.
Sectional Area.....47.66 inch.
Weight.....29 lbs.



Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	....	
10,000	0	....	
20,000	.0007	.....	
30,000	.0025	.....	
40,000	.0048	.....	
50,000	.0067	.....	
5,000	.....	.0005	
60,000	.0085	.....	
70,000	.0105	.....	
80,000	.0126	.....	
90,000	.0145	.....	
100,000	.0166	.....	
5,000	.....	.0004	
110,000	.0188	.....	
120,000	.0208	.....	
130,000	.0228	.....	
140,000	.0248	.....	
150,000	.0270	.....	
5,000	.....	0	
160,000	.0290	.....	
170,000	.0312	.....	
180,000	.0339	.....	
190,000	.0361	.....	
200,000	.0390	.....	
200,000	.0405	.....	After 3 min. rest.
200,000	.0421	.....	After 6 min. rest.
200,000	.....	.....	

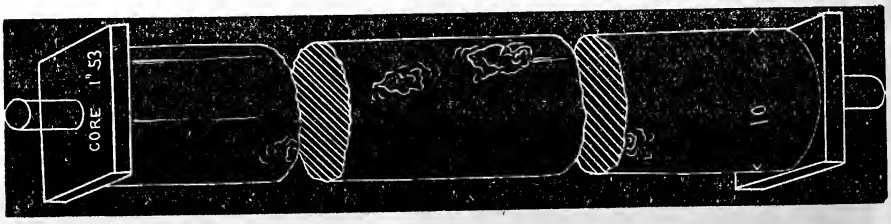
Rested over night, the packings of the machin- allowing the load to fall to 6000 lbs. While under strain of 200,000 lbs., cracks opened about a knot at the middle of the block. Maintaining this load about 15 minutes did not further weaken the block. The load was then gradually increased to 215,000 lbs. This load was sustained 30 minutes, and then the block failed rapidly, by opening longitudinal cracks.

Ultimate strength 215,000 lbs. = 4511 lbs. per square inch.

White Oak Post No. 2.

Weight.....372 lbs.
Length.....144 inches.
Diameter (outside).....10 "

Diameter of core.....1.6 inches
Sectional area.....76.7 sq. ins.
Tested with pintle ends.
Counterweighted at middle 170 pounds.



Loads applied. Pounds.	Deflections.						Remarks.
	1½ ft. from N. end.		Centre.		1½ ft. from S. end.		
	Horizon.	Vertical.	Horizon.	Vertical.	Horizon.	Vertical.	
5,000	0	0	0	0	0	0	
10,000	0	0	0	0	0	0	
20,000	0	0	0	0	0	0	
30,000	0	0	0	0	0	0	
40,000	0	0	0	0	0	0	
50,000	0	0	0	0	0	0	
60,000	0	0	0	+.02	0	+.02	
70,000	0	0	0	+.02	+.03	+.02	
80,000	0	0	0	+.02	+.03	+.02	
90,000	0	0	0	.03	+.03	.03	
100,000	0	0	0	.04	.04	.04	
105,000	0	0	0	.07	.05	.05	
110,000	0	0	0	.08	.05	.06	Slight snap'ng heard at 112,000.
115,000	0	0	0	.09	.05	.07	
120,000	0	0	0	.10	.05	.07	
125,000	0	0	0	.10	.05	.08	
130,000	0	0	0	.10	.05	.08	
135,000	—.02	0	—.05	.10	.06	.09	
140,000	—.03	0	—.06	.10	.06	.10	
145,000	—.04	0	—.06	.10	.06	.10	
150,000	—.04	0	—.07	.10	.06	.10	
155,000	—.05	0	—.10	.12	.06	.11	
160,000	—.06	0	—.12	.13	.06	.12	
160,000	—.07	0	—.13	.13	.06	.12	
5,000	—.02	—.02	—.05	0	.01	0	
160,000	—.07	0	—.13	.13	.06	.12	
165,000	—.08	0	—.15	.13	.06	.13	
170,000	—.08	0	—.17	.13	.06	.15	
175,000	—.09	0	—.18	.13	.06	.15	
180,000	—.09	0	—.21	.14	.07	.16	
185,000	—.10	0	—.26	.14	.07	.16	
190,000	—.12	0	—.36	.14	.08	.17	
190,000	—.16	0	—.47 —.50	.11	.07	.19	3 minutes' rest. 4 min. rest. Ult. strength.
190,000							
5,000	—.08	—.06	—.25	—.03	.04	.01	

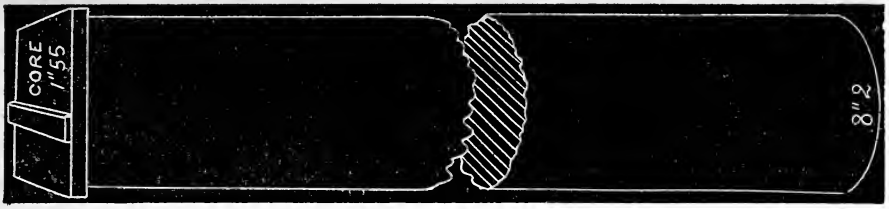
Post failed by horizontal deflection, the fibres giving way at a knot near the middle.
Pintles removed and post loaded with flat ends, taking full bearing on the compression platforms of the testing machine.

5,000			0	0			
50,000			0	.02			
100,000			—.03	+.05			
150,000			—.15	.07			
180,000			—.35	.10			
190,000			—.35	.10			
190,000			—.50	.10			3 minutes' rest.
190,000			—.62	.06			6 minutes' rest.
190,000			—.75	.03			9 minutes' rest.
190,000			—.90	0			12 minutes' rest.
190,000			—.95	0			Ultimate strength.
5,000			—.20				

Post sawed apart near middle, one end 6 feet 4 inches long tested, with flat ends taking a full bearing.
Strains applied rapidly. Failure occurred at 210,000 lbs. = 2733 lbs. per square inch, crumpling the fibres at two knots near the middle of its length.

White Oak Post No. 3.

Weight.....226 lbs.
Total length.....143.2 inches.
Gauged length.....140 inches.
Diameter (outside).....8.2 inches.
Diameter of core.....1.55 inches
Sectional area.....50.42 sq. inches.
Eccentricity.....1.91 inches.
Same plate and rod used as with yellow pine post No. 2.
Counterweighted at middle 126 pounds.



Loads applied. Pounds.	Compression Inches.	Permanent sets.	Deflections. Centre. Horizon.	Centre. Vertical.	2½ ft. from centre toward eccentric end. Horizon.	2½ ft. from centre toward eccentric end. Vertical.	Remarks.
5,000	0	.....	0	0	0	0	
10,000	.0040	.....	0	+.01	0	+.01	
20,000	.0130	.....	0	.10	0	.08	
30,000	.0220	.....	0	.12	0	.11	
40,000	.0318	.....	0	.18	0	.17	
50,000	.0400	.....	0	.22	0	.23	
5,000	.....	0	0	0	0	0	
60,000	.0475	.....	0	.30	0	.30	
70,000	.0548	.....	0	.38	0	.38	
80,000	.0609	.....	0	.46	0	.48	
90,000	.0652	.....	0	.60	0	.60	
90,000	.0621	.....	0	.70	0	.70	5 minutes' rest.
90,000	.0610	.....	0	.75	0	.75	10 minutes' rest.
90,000	.0585	.....	0	.80	0	.80	18 minutes' rest.
90,000	.0586	.....	0	.83	0	.82	23 minutes' rest.
95,000	.0586	.....	0	.90	0	.88	
95,000	.0586	.....	0	.98	0	.95	5 minutes' rest.
95,000	.0586	.....	0	1.00	0	.98	8 minutes' rest.
100,000	.0580	.....	0	1.10	0	1.08	
100,000	.0580	.....	0	1.30	0	1. 8	5 minutes' rest.
100,000	.....	.....	0	1.62	0	1.70	15 minutes' rest.
100,000	.....	.....	.....	.....	.....	.....	Ultimate strength.

Failed by deflecting upwards. Weakness developed at knots and generally throughout entire length of post. Test discontinued before much local weakness appeared.

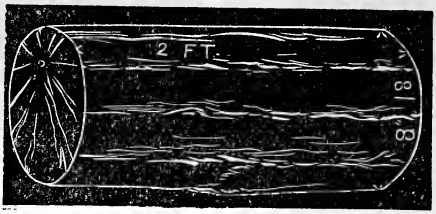
White Oak Block, No. 2.

Total length.....24.06 inches.
Gauged length.....18 inches.
Diameter.....9.98 inches.
Sectional area.....78.23 sq. ins.
Weight.....59 lbs.

Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	.....	
10,000	.0015	.....	
30,000	.0060	.....	
50,000	.0100	.....	
5,000	.....	.0004	
70,000	.0140	.....	
90,000	.0177	.....	
100,000	.0197	.....	
5,000	.....	.0006	
110,000	.0215	.....	
120,000	.0238	.....	
130,000	.0260	.....	
130,000	.0264	.....	5 minutes' rest.
140,000	.0285	.....	
140,000	.0290	.....	
150,000	.0310	.....	
150,000	.0315	.....	5 minutes' rest.
160,000	.0336	.....	
160,000	.0345	.....	5 minutes' rest.
170,000	.0364	.....	
170,000	.0380	.....	5 minutes' rest.
2,000	.....	.....	rested 15 h'rs; new gaugings begun.
5,000	.0319	.....	
175,000	.0382	.....	
175,000	.0403	.....	
180,000	.0415	.....	
180,000	.0425	.....	
185,000	.0439	.....	
185,000	.0451	.....	
190,000	.0469	.....	
190,000	.0484	.....	5 minutes' rest.
200,000	.0512	.....	
200,000	.0542	.....	5 minutes' rest.
210,000	.0630	.....	Load sustain'd 6 m, before gauge read.
210,000	.0680	.....	5 minutes' rest.
220,000	.0735	.....	
220,000	.0818	.....	5 minutes' rest.
225,000	.0867	.....	
225,000	.0994	.....	5 minutes' rest.
230,000	.1030	.....	
230,000	.1200	.....	5 minutes' rest.
235,000	.1240	.....	
235,000	.1520	.....	5 minutes' rest.
240,000	.1620	.....	
240,000	.2140	.....	5 minutes' rest.
245,000	.2240	.....	
245,000	.....	.....	5 m. rest. Fail. took place very rapidly.
245,000	.....	.....	Ult. strength = 3132 lbs. per sq. inch.

White Oak Block.—No. 3.

Total length.....24 inch.
Gauged length.....18 inch.
Diameter.....8.18 inch.
Sectional Area.....52.55 sq. inch.
Weight.....41 lbs.



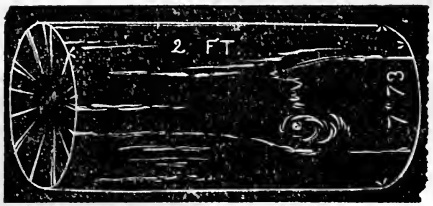
Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0	.....	
10,000	.0010	.....	
30,000	.0072	.....	
50,000	.0131	.....	
5,000	.....	.0001	
60,000	.0163	.....	
70,000	.0196	.....	
80,000	.0218	.....	
90,000	.0222	.....	
100,000	.0240	.....	
5,000	.....	.0020	
110,000	.03 5	.....	
130,000	.0390	.....	
140,000	.0465	.....	
150,000	.0622	.....	
150,000	.0845	.....	After 5 min. rest.
155,000	.0920	.....	
155,000	.1180	.....	After 5 min. rest.
160,000	.1271	.....	
160,000	.1790	.....	After 5 min. rest.
165,000	.1980	.....	
165,000	.3240	.....	After 5 min. rest.
165,000	.....	.....	Ult. strength = 3139 lbs. per sq. inch.

Failed by crumpling the fibres and opening longitudinal cracks. Rapid yielding began after the maximum load had been sustained 8 minutes.

Knots at the middle of the block in the vicinity of the fracture probably located the place of failure.

White Oak Block No. 4.

Total length	23 7/8 inches.
Gauged	18 inches.
Diameter	7.73 inches.
Sectional area	46.93 sq. ins.
Weight	36 lbs.



Loads applied. Pounds.	Compression. Inches.	Permanent sets.	Remarks.
5,000	0		
10,000	.0005		
20,000	.0031		
30,000	.0061		
40,000	.0090		
50,000	.0119		
5,000		0	
60,000	.0148		
70,000	.0185		
80,000	.0209		
90,000	.0239		
100,000	.0270		
5,000		.0016	
110,000	.0310		
120,000	.0353		
130,000	.0400		
140,000	.0 87		
140,000	.0560		After 5 min. rest.
140,000	.0605		After 10 min. rest.
140,000	.0650		After 15 min. rest.
140,000	.0699		After 20 min. rest.
140,000	.0750		After 25 min. rest.
140,000	.0820		After 30 min. rest.
140,000	.0909		After 35 min. rest.
140,000	.0990		After 40 min. rest.
140,000	.1102		After 45 min. rest.
140,000	.1204		After 50 min. rest.
140,000	.1274		After 55 min. rest.
140,000	.1350		After 60 min. rest.
140,000	.1408		After 65 min. rest.
145,000	.1450		
145,000	.1600		After 5 min. rest.
150,000	.1650		
150,000	.2040		After 5 min. rest.
155,000	.2150		
155,000	.3090		After 5 min. rest.
155,000	.4550		After 10 min. rest. Ult. str'gth 155,000 = 3303 per sq. in.

The maximum load, 155,000 lbs., had been carried 5 minutes, lines of failure were visible. These lines were more rapidly developed as time passed by, crumpling the fibres rapidly after 12 minutes' time.

OLD WHITE OAK POSTS FROM MILL No. 1.

No. 1914.

No. 1915.

Post No. 1914.

Weight	113	lbs.
Length	144.92	ins.
Gauged length	140	ins.
Diameter of larger end	6.84	ins.
Diameter of smaller end	5.85	ins.
Diameter of core	1.95	ins.
Sectional area at larger end	33.8	sq. ins.
Sectional area at smaller end	23.9	sq. ins.
Post not straight, versed-sine at middle	0.45	ins.

Ends brought to an even bearing.

Post had been in the mill about 6½ years.

Loads Applied. Pounds.	Compression. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0	0	0	0
10,000	.0112		.02	0
20,000	.0340		.08	0
5,000		.0006	0	0
30,000	.0658		.10	0
40,000	.0912		.15	0
50,000	.1204		.17	0
5,000		.0010		
60,000	.1480		.22	.05
70,000	.1762		.25	.07
80,000	.2050		.30	.10
90,000	.2345		.40	.13
100,000	.2640		.55	.16
5,000		.0062	.10	0
110,000*				

* Ultimate strength; equals 4602 lbs. per sq. in.; sustained about three minutes.

Horizontal deflection follows initial bending. When the maximum load had been sustained three minutes, the deflections gradually increasing, failure suddenly occurred, by the fibres giving way in the vicinity of some knots 60 inches from smaller end. The fibre of the wood has a dull, dead appearance.

Post No. 1915.

Weight	116	lbs.
Length	144.92	ins.
Gauged length	140	ins.
Diameter of larger end	6.85	ins.
Diameter of smaller end	5.85	ins.
Diameter of core	1.90	ins.
Sectional area at larger end	34	sq. ins.
Sectional area at smaller end	24	sq. ins.

Ends brought to an even bearing

Post had been in the mill about 6½ years.

Loads Applied. Pounds.	Compression. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0	0	0	0
10,000	.0112		0	0
20,000	.0345		—.05	0
5,000		0	0	0
30,000	.0570		—.06	0
40,000	.0790		—.10	0
50,000	.1010		—.10	0
5,000		—.0010	0	0
60,000	.1225		—.10	0
70,000*	.1445		—.10	0
80,000	.1670		—.10	+.08
90,000	.1884		—.12	+.12
100,000	.2113		—.12	+.12
5,000		—.0040	0	0
110,000			—.12	+.12
120,000			—.12	+.12
130,000			—.12	+.12
140,000			—.10	—.05
145,000†				

*Snapping sounds.

†Ultimate strength; equals 6032 lbs. per sq. in.

Failed by bending downwards. Fibres crumpled at knot 12 inches from smaller end. Opened longitudinal crack 42 inches from same end. At this point (42 inches from end) the maximum deflection took place when the maximum load was first passed. After continuing the deflection to —3 inches vertical deflection, the maximum deflection was near the middle.

No. 1916.

No. 1917.

Post No. 1916.

Weight	118	lbs.
Length	145.4	ins.
Gauged length	140	ins.
Diameter of larger end	6.70	ins.
Diameter of smaller end	5.87	ins.
Diameter of core	2	ins.
Sectional area at larger end	32.1	sq. ins.
Sectional area at smaller end	23.9	sq. ins.
About 20 inches from smaller end maximum versed-sine	0.25	ins.

Short bends in post.

Ends brought to an even bearing.

Post had been in mill about 6½ years.

Loads Applied. Pounds.	Compression. Inches.	Permanent sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0	0	0	0
10,000	.0990		0	0
20,000	.0475		—.05	—.05
5,000		0	0	0
30,000	.0754		—.10	—.10
40,000	.1022		—.10	—.10
50,000	.1300		—.10	—.10
5,000		.0015	0	0
60,000	.1588		—.14	—.10
70,000	.1885		—.16	—.14
80,000	.2190		—.20	—.20
90,000	.2555		—.25	—.25
5,000		.0108	—.05	0
100,000			—.32	—.32
110,000			—.50	—.45
112,660*				

* Ultimate strength; equals 4682 lbs. per sq. in.

Failed at some knots 25 inches from small end. Deflected downwards.

Post No. 1917.

Weight	113	lbs.
Length	144.6	ins.
Gauged length	140	ins.
Diameter of larger end	6.75	ins.
Diameter of smaller end	6.02	ins.
Diameter of core	1.95	ins.
Sectional area at larger end	32.8	sq. ins.
Sectional area at smaller end	25.5	sq. ins.
At 3 feet from large end versed-sine	0.50	ins.

Short bend near large end.

Tested with maple cap and oak base with grain at right angles to axis of post.

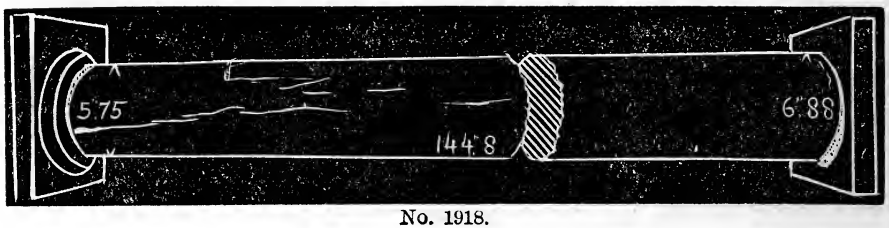
Ends not brought to an even bearing.

Post had been in the mill about 6½ years.

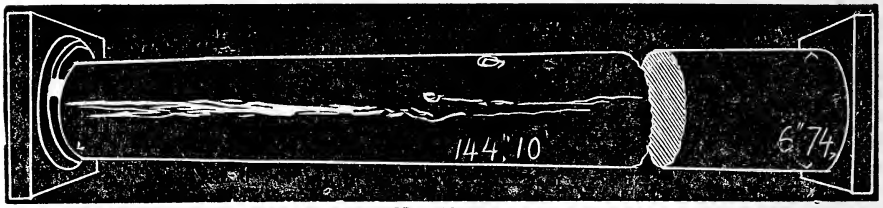
Loads Applied. Pounds.	Compression. Inches.	Permanent sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0	0	0	0
10,000	.0075		—.02	+.05
20,000	.0415		—.09	.09
5,000		—.0020	0	0
30,000	.0585			
40,000	.0895		—.10	.13
50,000	.1255		—.07	.14
5,000		.0050	0	0
60,000	.1670		0	.10
70,000	.2358		+.35	—.05
75,000*				

* Ultimate strength; equals 2943 lbs. per sq. in.

Sustained maximum load about 3 minutes and then failed rapidly, deflecting sideways to the west and downwards. Fibres crumpled at two knots at middle of post. The knots were on the concave side. Maple cap and oak base were most deeply indented on the west side. The deflection of the post was continued till the ends were relieved of their bearings on the east side of caps and base, the load being carried on the indented sides of cap and base.



No. 1918.



No. 1931.

Post No. 1918.

Weight	108	lbs.
Length	144.8	ins.
Diameter of larger end	6.88	ins.
Diameter of smaller end	5.75	ins.
Diameter of core	1.95	ins.
Sectional area at larger end	34.19	sq. ins.
Sectional area at smaller end	22.98	sq. ins.
Post not straight. Versed-sine at middle	1	in.

Compressions not measured. Tested with maple cap and oak base. Large end of post in a state of partial decay, reducing bearing surface to about one-fifth full section of end. Post had been in mill about 6½ years.

Loads Appl'd. Pounds.	Deflections. Hor.	Deflections. Vert.	Remarks.
5,000	0	0	Post placed in machine convex side up.
10,000	+.05	—.15	
20,000	.20	—.30	At large end bearing takes place at upper side only.
30,000	.39	—.40	
40,000	.64	—.50	
50,000	.85	—.55	
60,000	1.05	—.45	
70,000	1.35	—.22	
75,000	.....	.....	Ult. stg. = 3263 lbs. per sq. in.

Failed by deflecting horizontally and upward. Maximum load sustained about 2 minutes. As the loads were increased above the initial load of 5000 pounds, the fibres at the larger end gradually crumpled, till finally the post took a full bearing. After bearing the maximum load, deflections were increased till the fibres were broken at knots 20 inches to 40 inches from small end.

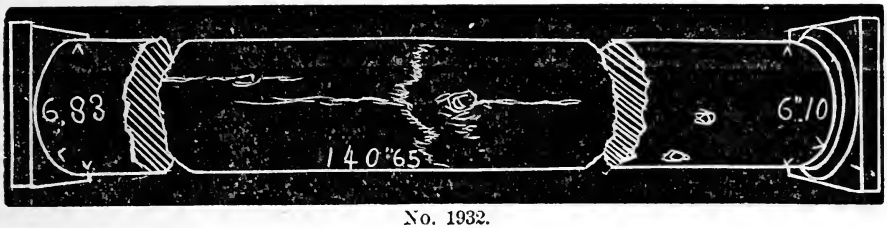
Post No. 1931.

Weight	118	lbs.
Length	144.10	ins.
Gauged length	140	ins.
Diameter of larger end	6.74	ins.
Diameter of smaller end	5.97	ins.
Diameter of core	1.92	ins.
Sectional area at larger end	32.78	sq. ins.
Sectional area at smaller end	25.10	sq. ins.

Ends not brought to an even bearing.
Tested with maple cap and oak base.
Post had been in mill about 6½ years.

Loads Applied. Pounds.	Compression. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical
5,000	0	.....	0	0
10,000	—.0020	.....	—.08	+.10
20,000	.0008	.....	—.14	+.20
5,000*	.....	—.0008	—.04	0
30,000†	.....	.....	—.20	.25
40,000	.....	.....	—.25	.30
50,000	.....	.....	—.30	.34
60,000	.....	.....	—.40	.40
70 000	.....	.....	—.46	.42
80,000	.....	.....	—.55	.46
90,000	.....	.....	—.65	.55
100,000	.....	.....	—1.05	.75
106,000‡	.....	.....	.....	.....

* Micrometer removed.
† Cracking sounds heard.
‡ Ultimate strength; equals 4223 lbs. per sq. in.
Failed by deflection; opened longitudinal seams.



No. 1932.

Post No. 1932.

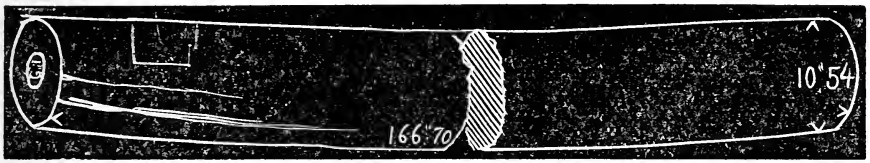
Weight	118	lbs.
Length	140.65	ins.
Gauged length	140	ins.
Diameter of smaller end	6.10	ins.
Diameter of larger end	6.83	ins.
Diameter of core	2	ins.
Sectional area of smaller end	26.08	sq. ins.
Sectional area of larger end	33.5	sq. ins.

Tested with maple cap and oak base.
Ends not brought to an even bearing.
Post had been in mill about 6½ years.

Loads Appl'd Pounds.	Deflections, Hor.	Deflections, Vert.	Remarks.
5,000	0	0	
10,000	0	0	
20,000	.05	.05	
30,000	.06	.06	
40,000	.10	.10	
50,000	.15	.10	
60,000	.20	.05	
70,000	.35	0	
80,000	.55	—.05	
90,000	1.40	—.30	Ult. stg. = 3450 lbs. per sq. in.

Failed at two knots at middle of post; knots were on the concave side.

OLD WHITE OAK POSTS FROM MILL No. 2 (PACIFIC MILLS).



Post A.

Post A.

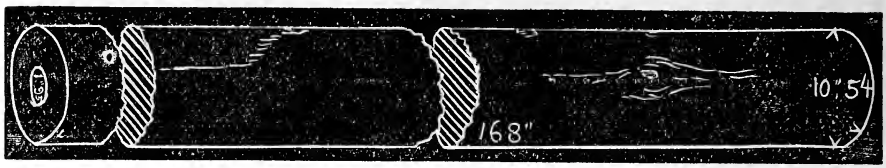
Weight	398	lbs.
Length	166.70	ins.
Diameter	10.54	ins.
Diameter of core	1.9	ins.
Sectional area	84.4	sq. ins.
Post not straight, versed-sine	1.6	ins.

Ends not brought to an even bearing.

Loads Applied. Pounds.	Deflections, Hor.	Deflections, Ver.	Remarks.
5,000	0	0	
10,000	—.06	0	
30,000	—.20	0	
50,000	—.26	0	
70,000	—.30	0	
90,000	—.28	0	
100,000	—.28	0	
120,000	—.28	0	
140,000	—.25	0	
160,000	—.22	—.05	
180,000	—.20	—.05	
200,000	—.18	—.05	Snapping sounds.
220,000	—.10	—.05	
240,000	—.08	—.05	
260,000	—.02	—.05	
280,000	+.02	—.06	
300,000	.10	—.08	
320,000	.18	—.10	
340,000	.25	—.10	
360,000	.....	.....	Ult. stg.=4265 lb. per sq.in.

Failed suddenly, opening a longitudinal seam. Broke with a loud report.

POST B.



POST C.

Post B.

Weight	360	lbs.
Length	165.4	ins.
Gauged length	140	ins.
Diameter	10.50	ins.
Diameter of core	1.9	ins.
Sectional area	83.76	sq. ins.

Post not straight, versed-sine about 0.40 ins., horizontal deflection, and about 0.40 of an inch vertical, both in minus direction. Stick has winding grain and season cracks filled with putty. Ends not adjusted to even bearings. Under initial load at north end upper side of post 0.20 of an inch short. South end upper side 0.15 of an inch short.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0		0	0
20,000	—.0105		.08	0
30,000	—.0205		.10	.05
40,000	—.0260		.15	.15
50,000	—.0275		.15	.15
10,000		—.0015	0	0
70,000	—.0260		.15	.20
90,000	—.0232		.15	.25
100 000	—.0200		.15	.28
10,000		—.0020	0	0
120,000	—.0130		.12	.32
140,000	—.0032		.12	.35
160,000	+.0080		.10	.38
180,000	.0212		.08	.40
200,000	.0360		.06	.40
10,000		.0030	0	0
220,000			0	.52
240,000*			0	.55
260,000			— 02	.60
280,000			—.05	.60
300,000			—.05	.60
320,000			—.12	.60
325,000†				

* Snapping sounds.

† Ultimate strength; equals 3880 lbs. per square inch.

Placed in machine with concave side up. Failed by splitting at end on the convex side. Up to 200,000 lbs. load, the ends had not come to a full bearing.

Post C.

Weight	383	lbs.
Length	168	ins.
Gauged length	140	ins.
Diameter	10.54	ins.
Diameter of core	1.95	ins.
Sectional area	87.26	sq. ins.

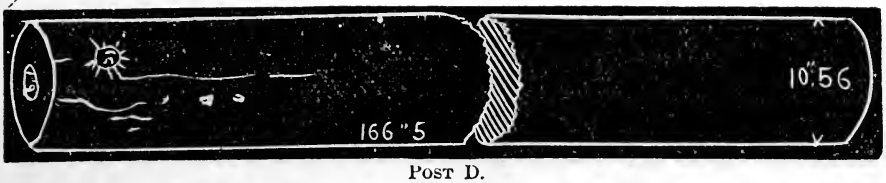
Ends not brought to an even bearing.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0		0	0
10,000	.0044		0	0
30,000	.0160		.10	.05
50,000	.0310		.10	.05
5,000		.0010	0	0
70,000	.0478		.10	.05
90,000*	.0640		.10	.05
100,000	.0720		.10	.05
5,000		.0015	0	0
120,000	.0890		.10	.05
140,000	.1055		.10	.05
150,000	.1141		.10	.05
5,000		.0016	0	0
170,000	.1300		.12	.05
190,000	.1472		.15	.05
200,000	.1560		.15	.05
5,000		.0020	0	0
220,000			.18	.05
240,000			.20	.05
260,000			.20	.05
280,000			.20	.05
300,000			.20	.05
320,000			.22	.05
340,000			.25	.05
360,000			.28	.05
380,000			.28	.10
400,000			.30	.10
410,000			.31	.12
420,000†			.35	.15

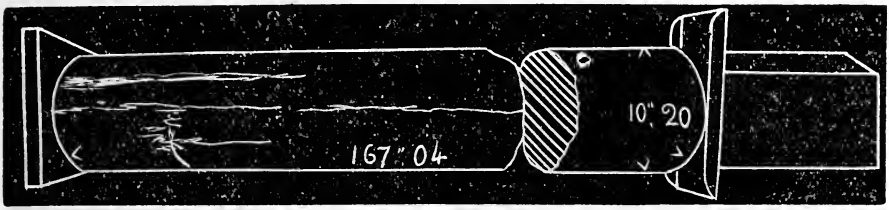
*Snapping sound.

†Ultimate strength; 4284 lbs. per sq. in.

Failed at knot about 5 feet from end. Post appeared shaky near this failure.



Post D.



Post E.

Post D

Weight..... 388 lbs.
Length..... 166.5 ins.
Gauged length..... 140 ins.
Diameter..... 10.56 ins.
Diameter of core..... 1.9 ins.
Sectional area..... 84.7 sq. ins.

Ends brought to even bearing by using brass packing.

Loads Applied. Pounds.	Compressions. Inches.	Permanent sets.	Deflections. Horizon.	Deflections. Vertical.
5,000	0	0	0	0
10,000	.0080		0	0
30,000	.0320		0	0
50,000	.0540		0	0
5,000		.0030	0	0
70,000	.0760		0	0
90,000	.0980		0	0
100,000	.1090		0	0
5,000		.0035	0	0
110,000	.1315		0	0
140,000	.1540		0	0
150,000	.1655		0	0
5,000		.0045	0	0
170,000	.1865		0	0
190,000	.2100		—.08	.05
200,000	.2225		—.10	.10
5,000		.0050	0	0
220,000	.2460		—.10	+.10
240,000	.2715		—.15	+.12
250,000	.2860		—.18	+.12
5,000		.0090	0	0
270,000	.3110		—.20	.12
290,000	.3410		—.22	.15
300,000	.3570		—.30	.15
5,000		.0180	0	0
320,000			—.30	.15
340,000			—.40	.15
345,000*			—.50	.15
350,000			—.50	.15
360,000			—.55	.15
370,000			—.60	.15
380,000			—.65	.12
390,000			—.80	.08
390,000†			—1.40	0
390,000‡				

*Sustained five minutes.

†After sustaining load five minutes.

‡Ultimate strength: 4604 lbs. per sq. in.

Failed by deflection, sideways, at knot, six inches from end; after passing the maximum load, the pressure was allowed to fall off to 380,000 lbs., and was maintained at this point about three minutes. Snapping sounds were heard frequently after passing 120,000 lbs. Convex side, after failure, on the side, having knot six inches from end.

Post E.

Weight..... 370 lbs.
Length..... 167.04 ins.
Gauged length..... 140. ins.
Diameter..... 10.20 ins.
Diameter of core..... 1.8 ins.
Pintle length..... 19.60 ins.
Sectional area..... 79.17 sq. ins.

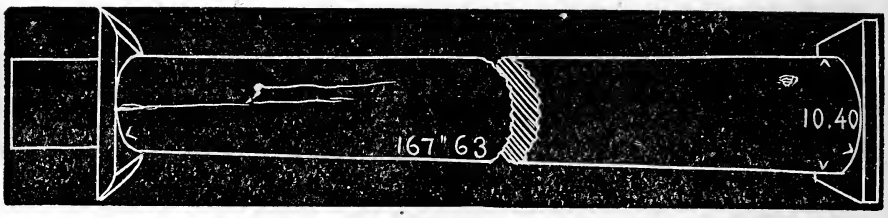
Ends not brought to an even bearing. Tested with base at one end; pintle and cap at one end.

Loads Applied. Pounds.	Compressions. Inches.	Permanent sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0		0	0
20,000	.0100		0	0
30,000	.0220		0	0
50,000	.0456		—.02	—.02
10,000		.0005	0	0
70,000	.0686		—.02	—.05
90,000	.0910		—.05	—.08
100,000	.1018		—.05	—.10
10,000		.0018	0	0
120,000	.1226		—.05	—.12
140,000	.1460		—.06	—.15
160,000	.1683		—.08	—.16
180 000*	.1910		—.10	—.16
200,000	.2140		—.10	—.18
10,000		.0036	0	—.08
220,000			—.10	—.20
240,000			—.13	—.24
260,000			—.15	—.25
280,000			—.18	—.28
300,000			—.22	—.30
320,000			—.28	—.33
340,000			—.36	—.36
360,000			—.64	—.40
370,000†			—.80	—.42

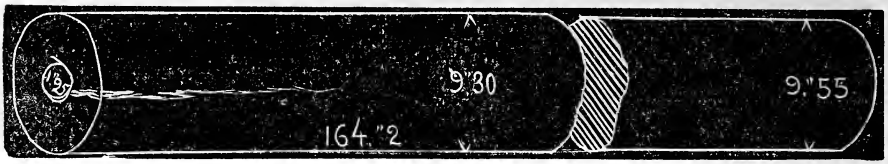
*Snapping sounds.

†Ultimate strength: 4662 lbs. per sq. in.

Failed suddenly at a knot 16 inches from the end used without pintle, crumpling the fibres and opening longitudinal seams.



POST F



POST G.

Post F.

Weight	378	lbs.
Length	167.63	ins.
Gauged length	140	ins.
Diameter	10.40	ins.
Diameter of core	1.7	ins.
Sectional area	82.68	sq. ins.

Tested with cap and pintle at one end; base at the other end. Ends not adjusted to an even bearing.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0		0	0
20,000	.0160		0	0
50,000*	.0461		—.03	0
10,000		.0040	—.04	0
70,000	.0632		—.08	.13
90,000	.0789		—.08	.15
100,000	.0872		—.08	.18
10,000		.0050	—.08	.20
120,000	.1040		—.12	.33
140,000	.1200		—.12	.36
160,000	.1362		—.12	.40
180,000	.1513		—.15	.40
200,000	.1670		—.15	.45
10,000		.0052	—.15	.40
220,000			—.25	.80
240,000			—.26	.80
260,000			—.30	.90
280,000			—.40	.95
300,000			—.40	1.00
320,000			—.40	1.00
340,000			—.40	1 10
360,000			—.40	1.20
370,000			—.40	1.30
380,000			—.42	1.32
390,000			—.45	1.36
400,000†			—.46	1.55

*Snapping sounds.

†Ultimate strength; 4838 lbs. per sq. in.

Sustained maximum load about 5 minutes. Failed by splitting post at pintle end, fracture occurring from 12 inches to 24 inches from end, Deflections increased after reaching maximum load.

Post G.

Weight	301	lbs.
Length	164.2	ins.
Diameter at ends	9.75	ins.
Middle diameter	9.3	ins.
Diameter of core	1.95	ins.
Sectional area	64.94	sq. ins.

Post not straight from end to end. One end takes full bearing, the other end bearing on lower side; open at top about 0.1 inch.

Loads Applied. Pounds.	Deflections. Hor.	Deflections. Ver.	Remarks.
10,000	0	0	
20,000	.05	.02	
30,000	.06	.06	
40,000	.08	.10	
50,000	.09	.11	
60,000	.10	.13	
70,000	.10	.14	
80,000	.10	.15	
90,000	.10	.16	
100,000	.10	.16	
110,000	.10	.17	Snapping sounds.
120,000	.10	.18	
130,000	.10	.19	
140,000	.11	.20	
150,000	.12	.20	
160,000	.12	.20	
170,000	.12	.20	
180,000	.13	.20	
190,000	.13	.20	
200,000	.14	.20	
210,000	.15	.20	
220,000	.15	.20	
230,000	.16	.20	
240,000	.17	.20	
250,000	.18	.20	
260,000	.19	.19	
270,000	.20	.17	
280,000	.20	.15	
290,000	.21	.13	
300,000	.23	.10	
310,000	.30	0	
317,000			Ult. stg.=4881 lb. per sq.in.

Failed at some knots 5 feet from end.

POST H.

POST I.

Post H.

Weight	293 lbs.
Length	164.08 ins.
Diameter at top	9.5 ins.
Average diameter	9.25 ins.
Diameter of core	1.9 ins.
Sectional area	64.37 sq. ins.

Post not straight from end to end. Upper end takes an even bearing; lower end bears on one side, about 0.08 of an inch off at other side.

Loads Applied. Pounds.	Deflections. Hor.	Deflections. Ver.	Remarks.
10,000	0	0	
20,000	0	—.06	
30,000	0	—.14	
40,000	—.03	—.19	Lower end takes full bearing.
50,000	—.04	—.20	
60,000	—.05	—.20	
70,000	—.06	—.20	
80,000	—.06	—.20	
90,000	—.08	—.20	
100,000	—.08	—.21	
110,000	—.10	—.21	
120,000	—.10	—.21	Snapping sounds.
130,000	—.11	—.21	
140,000	—.12	—.21	
150,000	—.13	—.21	
160,000	—.14	—.20	
170,000	—.15	—.21	
180,000	—.17	—.21	
190,000	—.21	—.21	
200,000	—.25	—.22	
210,000	—.30	—.26	
220,000	—.37	—.29	
221,000			Ult. stg.=3433 lb. per sq.in.

Took triple (?) flexure towards end of test. Deflections not measured at maximum points. Deflection continued till post suddenly broke about 42 inches from end.

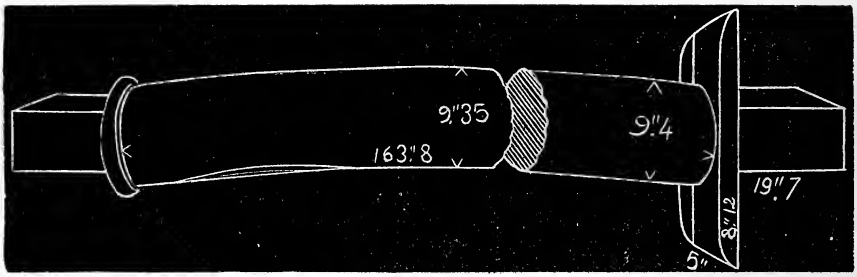
Post I.

Weight	267 lbs.
Length	163.8 ins.
Diameter	9.4 ins.
Diameter of core	1.9 ins.
Sectional area	66.56 sq. ins.

Post not straight from end to end. Ends do not take a full bearing. Open about 0.08 at top, each end.

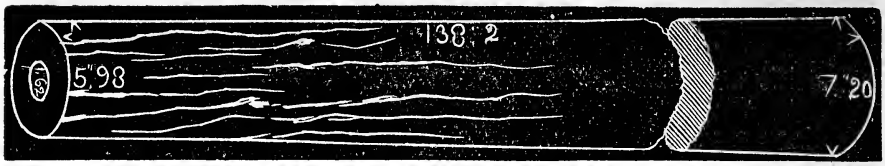
Loads Applied. Pounds.	Deflections. Hor.	Deflections. Ver.	Remarks.
10,000	0	0	
20,000	.06	.01	
30,000	.12	.03	
40,000	.13	.05	
50,000	.15	.06	Ends take full bearing.
60,000	.17	.07	
70,000	.18	.07	
80,000	.19	.07	
90,000	.20	.06	
100,000	.20	.05	
110,000	.20	.04	
120,000	.20	.02	
130,000	.20	0	
140,000	.20	0	
150,000	.20	—.02	
160,000	.20	—.04	
170,000	.20	—.06	
180,000	.19	—.10	
190,000	.19	—.11	
200,000	.18	—.15	
210,000	.18	—.18	
220,000	.17	—.24	
230,000	.17	—.30	
240,000	.16	—.31	
250,000	.16	—.48	
260,000	.16	—.73	
265,000	.16	—.13	Ult. stg.=3981 lb. per sq.in.

Failed by deflecting downward. Sustained maximum load 5 minutes, deflection increasing rapidly near the close of the test.



POST J

OLD WHITE OAK POSTS FROM MILL No. 3.



Post J.

Weight	310	lbs.
Length	163.8	ins.
Diameter	9.35	ins.
Diameter of core	1.9	ins.
Sectional area	65.83	sq. ins.

Pos not straight from end to end. Tested with pintle at each end, round base between pintle and post at one end; rectangular cap between post and pintle at the other end. Pintles placed with major axis horizontal.

Length of pintle	19.7	ins.
Outside dimensions of section of pintle	5x8.5	ins.
Inside dimensions of section of pintle	3.75x7.1	ins.

Post takes full bearing at the bottom on base, base standing off from pintle about 0.10 ins. under side. Uneven bearing at the top standing off in places about 0.20 ins. from cap. Side of post about 40 ins. from one end gouged out to a depth of ⅞ ins. and 20 ins. long.

Loads Applied. Pounds.	Deflections, Hor.	Deflections, Ver.	Remarks.
10,000	0	0	
20,000	0	—.06	
30,000	—.03	—.10	
40,000	—.06	—.12	
50,000	—.10	—.15	
60,000	—.10	—.16	
70,000	—.12	—.17	
80,000	—.14	—.18	
90,000	—.18	—.18	
100,000	—.20	—.18	
110,000	—.22	—.16	
120,000	—.26	—.13	
130,000	—.28	—.12	
140,000	—.30	—.10	
150,000	—.33	—.10	
160,000	—.38	—.07	
170,000	—.40	—.05	
180,000	—.46	—.02	
190,000	—.52	0	
200,000	—.60	+.02	
210,000	—.70	+.10	
214,000	.....	.....	Sudden snaps increasing ver. deflection.
100,000	.....	.....	
214,000	—.88	.50	
215,650	—1.10	.80	Ult. stg.—3266 lb. per sq. in.

Sustained maximum load 5 minutes. Deflected, following the initial bend in post The side gouged out being on the concave side. Cast iron base found to be split when post was removed from machine.

OLD WHITE OAK POST FROM MILL No. 3.

Weight	121	lbs.
Length	138.2	ins.
Diameter of larger end	7.20	ins.
Diameter of smaller end	5.98	ins.
Diameter of core	1.62	ins.
Sectional area of larger end	33.65	sq. ins.
Sectional area of smaller end	26.03	sq. ins.

Compressions not measured.

Loads Applied. Pounds.	Deflections, Hor.	Deflections, Ver.	Remarks.
5,000	0	0	
10,000	0	—.05	
20,000	+.05	—.10	
30,000	.05	—.13	
40,000	.05	—.15	
50,000	.05	—.15	
60,000	.10	—.20	
70,000	.10	—.20	
80,000	.10	—.20	
90,000	.10	—.20	
100,000	.10	—.25	
110,000	.10	—.30	
120,000	.16	—.30	
130,000	.20	—.35	
140,000	.25	—.40	
150,000	.35	—.52	
160,000	.....	.....	Ult. stg.—6147 lb. per sq. in.

Sustained maximum load about three minutes; then failed suddenly, deflecting downward. Fibers crumpled at knots from 22 inches to 32 inches from smaller end, and longitudinal cracks were opened.

SECOND SERIES.

WHITE OAK POST NO. 1.

WHITE OAK POST NO. 4.

SECOND SERIES.

White Oak Post No. 1.

Weight ..... 451 lbs.
Length ..... 143.4 ins.
Gauged length ..... 140 ins.
Diameter ..... 10.45 ins.
Diameter of core ..... 1.6 ins.
Sectional area ..... 92.16 sq. ins.

Tested with one flat end; one end with rounded bearing; vertical axis placed eccentric 2.75 ins.

Loads Applied. Pounds.	Deflections. Hor.	Deflections. Ver.	Remarks.
10,000	0	0	
20,000	0	0	
40,000	.10	.04	
50,000	.12	.05	
10,000	0	0	
70,000	.20	.10	
90,000	.22	.12	
100,000	.26	.12	
10,000	0	.10	
120,000	.30	.15	
140,000	.40	.16	
150,000	.45	.20	
10,000	0	.15	
170,000	.52	.40	Ultimate strength.

Crumpled fibres and split post at end, on side receiving eccentric loading.

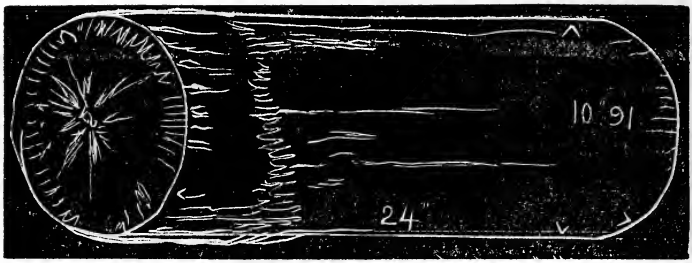
White Oak Post No. 4.

Weight ..... 200 lbs.
Length ..... 144 ins.
Gauged length ..... 140 ins.
Diameter ..... 7.74 ins.
Diameter of core ..... 1.60 ins.
Sectional area ..... 45.04 sq. ins.

Ends adjusted to even bearings.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0	.....	0	0
20,000	.0200	.....	0	0
40,000	.0618	.....	0	0
60,000	.0825	.....	0	0
10,000	.....	.0025	0	0
70,000	.1258	.....	.02	—.04
90,000	.1733	.....	.02	—.06
100,000	.2000	.....	.02	—.10
10,000	.....	.6138	.10	—.20
120,000	.2550	.....	.10	—.30
140,000	.....	.....	.10	—.60
145,000*	.....	.....	.....	.....

* Ultimate strength; 3219 lbs. per sq. in.
Failed by deflecting horizontally and downward.



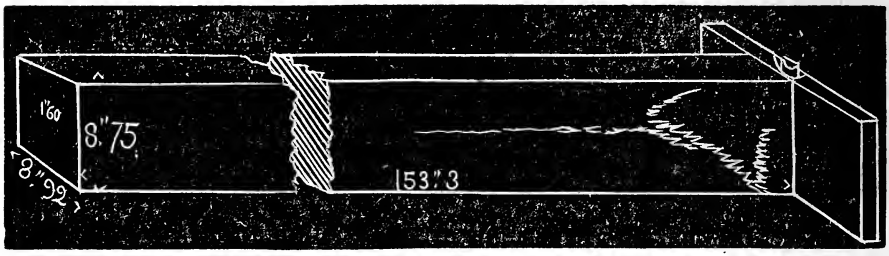
WHITE OAK BLOCK NO. 1.

White Oak Block No. 1.

Weight	72	lbs.
Length	24	ins.
Diameter	10.91	ins.
Sectional area	93.48	sq. ins.

Ultimate strength equals 416,000 lbs., equals 4450 lbs per sq. in. Crumpled fibres near the end of block.

THIRD SERIES.



YELLOW PINE SQUARE POST NO. 1.

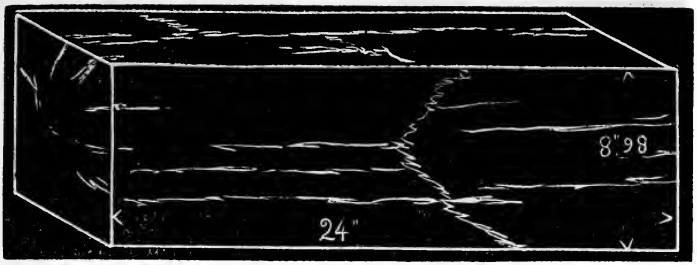
Yellow Pine Square Post No. 1.

Weight	386	lbs.
Length	153.3	ins.
Gauged length	140	ins.
Rectangular section	8.75x8.92	ins.
Diameter of core	1.00	ins.
Sectional area	76.01	sq. ins.

Tested with one flat end; one end with rounded bearing; vertical axis eccentric, 2.25 inches. Radius, rounded end, 4 inches.

Loads Applied. Pounds.	Deflections. Hor.	Deflections. Ver.	Remarks.
10,000	0	0	
20,000	0	0	
40,000	+.10	—.03	
50,000	+.10	—.03	
10,000	0	—.03	
70,000	.16	—.03	
90,000	.20	—.03	
100,000	.23	—.03	
110,000	0	—.03	
120,000	.28	—.03	
140,000	.32	—.03	
160,000	.40	—.03	
180,000	.48	—.03	
200,000	.55	—.03	
220,000	.60	—.03	
240,000	.70	—.03	
260,000	.78	—.03	
280,000	.96	—.03	Ultimate strength.

Sustained maximum load about two minutes. Failed by crumpling the fibres six inches from end on side receiving the eccentric load, and splitting post at end.

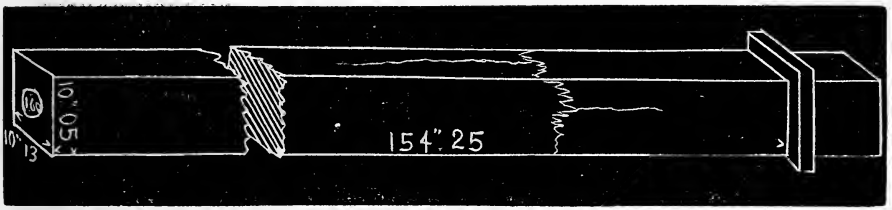


YELLOW PINE SQUARE BLOCK NO. 1.

Yellow Pine Square Block No. 1.

Weight ..... 58 lbs.
Length ..... 24 ins.
Rectangular section ..... 8.98x9.02 ins.
Sectional area ..... 81 sq. ins

Ultimate strength equals 412,000 lbs., equals 5050 lbs. per sq. in. Failed by crumpling fibres.



YELLOW PINE SQUARE POST NO. 2.

Yellow Pine Square Post No. 2.

Weight ..... 428 lbs.
Length ..... 154.25 ins.
Gauged length ..... 140 ins.
Rectangular section ..... 10.05x10.13 ins.
Diameter of core ..... 1.60 ins.
Sectional area ..... 99.8 sq. ins.

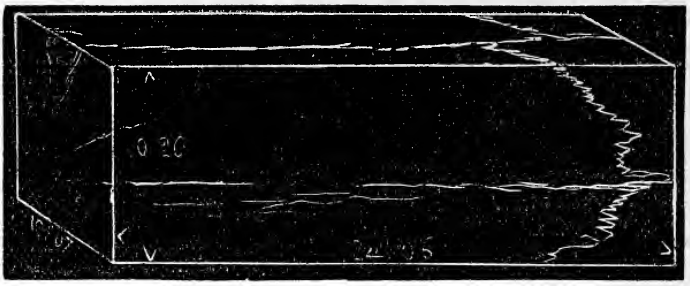
Tested with one flat end, one end with pintle. Same pintle used as on column from Mill No. 2, marked E; 8.45 inches, axis of pintle vertical, upper edge planed off 1-16 of an inch, uniform taper and 0 at lower edge.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0		0	0
20,000	.0025		0	0
40,000	.0076		—.03	.05
60,000	.0140		—.06	.12
80,000	.0220		—.06	.15
100,000	.0322		—.08	.18
10[illegible]		0	0	0
120,000	.0435		—.10	.20
140,000	.0558		—.10	.20
160,000	.0690		—.10	.20
180,000	.0822		—.10	.20
200,000	.0960		—.10	.20
10,000		0	0	0
220,000			—.12	.25
240,000			—.12	.25
260,000			—.12	.25
280,000			—.12	.25
300,000*			—.15	.26
320,000			—.16	.26
340,000			—.18	.26
360,000			—.20	.28
380,000			—.20	.28
400,000			—.20	.28
420,000			—.20	.28
440,000			—.20	.30
460,000			—.21	.30
480,000			—.32	.38
500,000			—.40	.42
510,000†				

*Snapping sounds.

†Ultimate strength; 5220 lbs. per sq. in.

Failed by horizontal deflection and upward crumpled fibres near middle of post.



YELLOW PINE SQUARE BLOCK NO. 2.

Yellow Pine Square Block No. 2.

Weight..... 62.5 lbs.
Length..... 24.06 ins.
Rectangular section..... 10.2x10.07 ins.
Sectional area..... 102.7 sq. ins.

Ultimate strength, 560,000 lbs., equals 5452 lbs. per sq. in. Failed by crumpling fibres.

YELLOW PINE ROUND POST NO. 3.

Yellow Pine Round Post No. 3.

Weight..... 213 lbs.
Length..... 167.9 ins.
Gauged length..... 140 ins.
Diameter..... 7.9 ns.
Diameter of core..... 1.60 ins.
Sectional area..... 47.01 sq. ins.

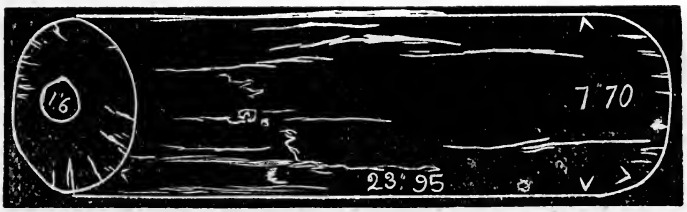
Tested with flat ends. This post was sawed down from 16 feet long.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections. Horizon.	Deflections. Vertical.
10,000	0	.....	0	0
20,000	.0136	.....	0	0
30,000	.0275	.....	0	0
40,000	.0415	.....	0	0
50,000	.0560	.....	0	0
10,000	.....	.0010	0	0
60,000	.0700	.....	0	0
70,000*	.0868	.....	0	0
80,000	.1011	.....	0	0
90,000	.1162	.....	.01	0
100,000	.1320	.....	.03	0
10,000	.....	.0030	0	0
110,000	.1480	.....	.08	—.08
120,000	.1650	.....	.10	—.10
130,000	.1815	.....	.10	—.10
140,000	.1990	.....	.10	—.10
150,000	.2160	.....	.12	—.12
10,000	.....	.0072	.10	—.10
160,000	.....	.....	.18	—.20
170,000	.....	.....	.18	—.20
180,000	.....	.....	.18	—.20
190,000	.....	.....	.18	—.24
200,000†	.....	.....	.10	—.28

* Snapping sounds.

† Ultimate strength; 4254 lbs. per sq. in.

Failed by deflection downwards and sideways, crumpling the fibres near the middle.



YELLOW PINE ROUND BLOCK NO. 3.

Yellow Pine Round Block No. 3.

Sawed from one end of post

Weight	25	lbs.
Length	23.95	ins
Diameter	7.7	ins
Diameter of core	1.6	ins
Sectional area	44.56	sq. ins.

Ultimate strength equals 218,000 lbs., equals 4892 lbs. per sq. in. Failed by crumpling fibres and splitting block.

YELLOW PINE ROUND POST NO. 4.

Yellow Pine Round Post No 4.

Weight	193	lbs.
Length	143.04	ins.
Gauged length	140	ins,
Diameter		lbs.
Diameter of core	1.6	ins
Sectional area	48.26	sq. ins

One flat end, one end with rounded bearing, vertical axis.

Loads Applied. Pounds.	Compressions. Inches.	Permanent Sets.	Deflections, Horizon.	Deflections, Vertical.
10,000	0		0	0
20,000	.0110		0	0
30,000	.0215		.01	0
40,000	.0330		.08	0
50, 00	.0448		.10	—.04
10,000		.0010	0	0
60,000	.0570		.12	—.10
70,000	.0692		.12	—.16
80,000	.0810		.15	—.16
90,000	.0940		.20	—.15
100,000*	.1060		.20	—.18
10,000		.0030	.19	—.16
110,000			.12	—.18
120,000			.14	—.20
130,000			16	—.20
140,000			20	—.22
150,000			22	—.22
160,000			25	—.30
170,000			30	—.32
180,000			35	—.35
190,000			40	—.40
200,000			45	—.42
210,000			56	—.50
220,000			70	—.55
225,000†				

*Snapping sounds,

†Ultimate strength; 4662 lbs. per sq. in.

Failed by deflecting sideways and downwards, crumpled fibres at flat end and near middle of post.

YELLOW PINE ROUND BLOCK NO. 4.

Yellow Pine Round Block No. 4.

Sawed from one end of post.

Weight	29.5	lbs.
Length	23.8	ins.
Diameter	7.98	ins.
Diameter of core	1.6	ins.
Sectional area	48	sq. ins.

Ultimate strength, 173,000 lbs., equals 3604 lbs. per sq. in.

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